VERIFICATION TEST PLAN
FOR
Hydro Compliance Management, Inc.
Hydro-Kleen™ Filtration System

Prepared for
NSF International
Ann Arbor, Michigan
And
The Environmental Technology Verification Program
Of the
US Environmental Protection Agency
Edison, New Jersey

By

Scherger Associates
Huntersville, North Carolina

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TABLE OF CONTENTS

List of Figures

List of Tables

Appendices

Abbreviations and Acronyms

ASTM	American Society for Testing and Materials
BETX	Benzene, Ethylbenzene, Toluene, Xylene
°C	Celsius degrees
COD	Chemical Oxygen Demand
DQI	Data Quality Indicators
USEPA	U.S. Environmental Protection Agency
ESWTR	Enhanced Surface Water Treatment Rule
ETV	Environmental Technology Verification
FOD	Field Operations Document
ft^2	Square foot (feet)
gal	Gallons
gpm	Gallon(s) per minute
GP	Generic Protocol – In Drain Treatment Technologies
HCM	Hydro Compliance Management, Inc.
J_t	Permeate flux
Kg	Kilogram(s)
L	Liters
Lbs	Pounds
MBAS	Methylene Blue Active Substances
MDL	Minimum Detection Level
NRMRL	National Risk Management Research Laboratory
μg/L	Microgram(s) per liter (ppb)
mgd	Million gallon(s) per day
mg/L	Milligram(s) per liter
mL	Milliliter(s)
NSF	NSF International, formerly known as National Sanitation Foundation
NIST	National Institute of Standards and Technology
O & G	Oil and Grease
O&M	Operations and Maintenance
PM	Project Manager for the Testing Organization (TO)
ppb	Parts per billion (μg/L)
QA	Quality assurance
QC	Quality control
RPD	Relative Percent Difference
SOP	Standard Operating Procedure
T	Temperature
TCLP	Toxicity Characteristic Leaching Procedure
TDS	Total dissolved solids
TKN	Total Kjeldahl Nitrogen
TO	Testing Organization
TOC	Total organic carbon
TPH	Total Petroleum Hydrocarbons

TSS	Total suspended solids
VO	Verification Organization (NSF)
VTP	Verification Test Plan

Glossary of Terms

Accuracy - a measure of the closeness of an individual measurement or the average of a number of measurements to the true value and includes random error and systematic error.

Bias - the systematic or persistent distortion of a measurement process that causes errors in one direction.

Commissioning – the installation of the in drain removal technology and start-up of the technology using test site wastewater.

Comparability – a qualitative term that expresses confidence that two data sets can contribute to a common analysis and interpolation.

Completeness – a qualitative term that expresses confidence that all necessary data have been included.

Precision - a measure of the agreement between replicate measurements of the same property made under similar conditions.

Protocol – a written document that clearly states the objectives, goals, scope and procedures for the study. A protocol shall be used for reference during Vendor participation in the verification testing program.

Quality Assurance Project Plan – a written document that describes the implementation of quality assurance and quality control activities during the life cycle of the project.

Residuals – the waste streams, excluding final effluent, which are retained by or discharged from the technology.

Representativeness - a measure of the degree to which data accurately and precisely represent a characteristic of a population parameter at a sampling point, a process condition, or environmental condition.

Source Water Protection Stakeholder Advisory Group - a group of individuals consisting of any or all of the following: buyers and users of in drain removal and other technologies, developers and vendors, consulting engineers, the finance and export communities, and permit writers and regulators.

Standard Operating Procedure – a written document containing specific procedures and protocols to ensure that quality assurance requirements are maintained.

Technology Panel - a group of individuals with expertise and knowledge of in drain treatment technologies.

Testing Organization – an independent organization qualified by the Verification Organization to conduct studies and testing of mercury amalgam removal technologies in accordance with protocols and Test Plans. Same as Field Testing Organization (see above).

Vendor – a business that assembles or sells in drain treatment equipment.

Verification – to establish evidence on the performance of in drain treatment technologies under specific conditions, following a predetermined study protocol(s) and Test Plan(s).

Verification Organization – an organization qualified by USEPA to verify environmental technologies and to issue Verification Statements and Verification Reports.

Verification Report – a written document containing all raw and analyzed data, all QA/QC data sheets, descriptions of all collected data, a detailed description of all procedures and methods used in the verification testing, and all QA/QC results. The Test Plan(s) shall be included as part of this document.

Verification Statement – a document that summarizes the Verification Report reviewed and approved and signed by USEPA and NSF.

Verification Test Plan – A written document prepared to describe the procedures for conducting a test or study according to the verification protocol requirements for the application of in drain treatment technology. At a minimum, the Test Plan shall include detailed instructions for sample and data collection, sample handling and preservation, precision, accuracy, goals, and quality assurance and quality control requirements relevant to the technology and application.

1.0 INTRODUCTION AND OBJECTIVES

1.1 INTRODUCTION

This document contains the technology specific Verification Test Plan (VTP) to be used for the verification testing of the Hydro Compliance Management, Inc, Hydro-Kleen™ Filtration System. The Hydro-Kleen™ Filtration System is a patented multi-media filtration design that includes sediment containment, absorption media, and overflow protection. The unit is designed for use in catch basins and drain inverts as an in-drain treatment technology. This Verification Test Plan has been prepared in accordance with the Protocol for the Verification of In-Drain Treatment Technologies (April 2001) developed under the United States Environmental Protection Agency (USEPA) Environmental Technologies Verification (ETV) program's Source Water Protection Pilot.

The USEPA ETV Program is intended to:

- Evaluate the performance of innovative and commercially available environmental technologies;
- Provide permit writers, buyers and users, among others, with objective information about technology performance; and,
- Facilitate "real world" implementation of promising technologies.

The ETV program has developed verification testing protocols that are intended to serve as templates for conducting verification tests for various technologies. The Protocol for the Verification of In-Drain Treatment Technologies was published as the guidance document for Test Plan development for verification testing of in-drain treatment units used in stormwater collection systems.. This VTP was developed in accordance with the guidance document. The goal of the verification testing process is to generate high quality data for verification of equipment performance.

The ETV Program is subdivided into twelve individual pilot projects, one of which is the Source Water Protection Pilot. This Pilot includes the verification testing of in-drain treatment technologies that are installed in stormwater collection systems and that provide protection for groundwater and surface water sources.

NSF International (NSF) oversees the verification testing pilot project for in-drain treatment technologies under the sponsorship of the USEPA Urban Watershed Branch, Water Supply and Resources Division. The role of NSF is to provide technical and administrative leadership in conducting the testing.

It is important to note that verification of the equipment does not mean that the equipment is "certified" or "approved" by NSF or USEPA. Instead, the verification testing pilot projects are a formal mechanism by which the performance of equipment can be determined by these two agencies, and which can result in the issuance of a Verification Statement by NSF and USEPA.

1.2 OBJECTIVES

Hydro Compliance Management, Inc. (Hydro Compliance) manufactures an in-drain treatment technology, the Hydro-Kleen™ Filtration System, which is designed to reduce the amount of sediment (and contaminants attached to the sediment) and hydrocarbons that are present in stormwater runoff. The individual units are designed to operate as inserts placed in catch basins and drain inlets. The treatment unit that will be tested in this verification is a full scale, commercially available unit.

Verification testing of in-drain treatment systems under the ETV Source Water Protection Pilot for In-Drain Treatment Technologies is designed to verify the contaminate removal performance and operational and maintenance performance of commercial-ready systems, following sound protocols and appropriate quality assurance and control. A primary objective of the ETV is to measure the performance of these technologies through a well-defined Test Plan that includes measurement of various contaminants, typically present in maintenance areas, parking lots, gasoline stations, truck stops and the "first flush" from stormwater, before and after application of the treatment technology.

The objective of this VTP is to determine the performance that is attained by the Hydro-Kleen™ Filtration System when used to treat water containing a variety of solid materials and petroleum hydrocarbons. Reduction in contaminate loads will be evaluated to determine the effectiveness of the system to remove suspended solids and various types of hydrocarbons.

The objective will be achieved by implementing testing procedures presented in this Verification Test Plan. A synthesized wastewater containing solids, petroleum hydrocarbons, surfactants, nutrients, and metals will be prepared using products typically found in stormwater runoff. The treatment system will be challenged under a variety of hydraulic loading conditions and contaminate loads. Influent and effluent samples from the unit will be measured for various contaminants as determined by indicator tests (e.g., Chemical Oxygen Demand, Total Petroleum Hydrocarbons, Total Suspended Solids) and by chemical specific tests (e.g., Benzene, Toluene, Phosphorus). The results will be used to calculate removal efficiencies, system capacities, and to determine the system treatment effectiveness. The Hydro-Kleen™ Filtration System is targeted for treatment of settleable solids and hydrocarbons. In addition to these parameters, other parameters will be monitored as secondary constituents to meet the ETV objective of providing an overall assessment of the technology that can be used by permit writers, buyers, and users of the technology.

The treatment system will also be monitored for operation and maintenance characteristics, including the performance and reliability of the equipment and the level of operator maintenance required. Data will be collected on the generation of residues. At the end of each test period, solids accumulated in the unit will be collected and measured. The absorbent media will also be changed at the end of certain phases of testing and will be measured for weight and volume.

2.0 VERIFICATION TESTING RESPONSIBILITES

EPA sponsors the ETV Program, which is implemented through contracted Verification Organizations (VO). NSF International is the VO for the ETV Source Water Protection Pilot. The VO is responsible to provide oversight for the testing program, and for selection of the Testing Organization (TO) for each technology to be verified. NSF reviews all Test Plans and oversees all of the participants in the testing program to ensure there is no bias or conflict of interest that could influence the test results. The NSF Hydraulics Laboratory and its personnel, the NSF Quality Assurance Support, and Scherger Associates will act as the Testing Organization, and the NSF Pilot Manager and designate will act as the Verification Organization. No person shall assume the responsibility of being part of both the Verification Organization and the Testing Organization. The NSF VO team will be completely separate from the NSF TO team members. The NSF VO team will provide independent review and oversight using staff and managers not involved in the day-to-day Testing Organization work.

2.1 NSF International - Verification Organization

The ETV Source Water Protection Pilot is administered through a cooperative agreement between USEPA and NSF its verification partner organization for the Source Water Protection Technologies Pilot. NSF administers the Pilot, and the development and implementation of the Verification Test Plan (VTP).

NSF's responsibilities as the Verification Organization include:

- Review and comment on the site specific Test Plan;
- Coordinate with peer-reviewers to review and comment on the Test Plan;
- Coordinate with the EPA Pilot Manager and the technology vendor to approve the Test Plan prior to the initiation of verification testing;
- Review the quality systems of all parties involved with the Testing Organization and subsequently, qualify the Testing Organization;
- Oversee the technology evaluation and associated laboratory testing;
- Carry out an on-site audit of test procedures;
- Oversee the development of a Verification Report and verification statement;
- Coordinate with EPA to approve the Verification Report and verification statement;
- Provide QA/QC Review and Support for the TO.

Key contacts at NSF for the Verification Test Plan and Program are:

Mr. Thomas Stevens, Pilot Manager
(734) 769-5347 email: Stevenst@NSF.org

Ms. Maren Roush, Project Coordinator
(734) 827-6821 email: MRoush@NSF.org

NSF International
789 Dixboro Road
Ann Arbor, Michigan 48105
(734) 769-8010

2.2 U.S. ENVIRONMENTAL PROTECTION AGENCY

The USEPA Office of Research and Development through the Urban Watershed Branch, Water Supply and Water Resources Division, National Risk Management Research Laboratory (NRMRL) provides administrative, technical, and quality assurance guidance and oversight on all ETV Source Water Protection pilot activities. The USEPA will review and approve each phase of the verification project. The USEPA's responsibilities will include:

- Verification Test Plan review and approval;
- Verification Report review and approval; and
- Verification Statement review and approval.

The key USEPA contact for this program is:

Mr. Ray Frederick, Project Officer, ETV Source Water Protection Pilot
(732) 321-6627 email: Frederick.Ray@epa.gov

USEPA, NRMRL
Urban Watershed Management Research Laboratory
2890 Woodbridge Ave. (MS-104)
Edison, NJ 08837-3679

2.3 TESTING ORGANIZATION

The TO for the verification testing is the NSF International laboratory, with support from Scherger Associates for Test Plan development and report preparation. The NSF Hydraulics Laboratory has the space and large-scale equipment (tanks, pumps, etc.) to perform the testing on the Hydro-Kleen unit, and the NSF Chemical Laboratory has the equipment and experience to perform the analytical work for this Test Plan. Scherger Associates has experience in Test Plan development and Verification Report writing and will support the NSF laboratory in these areas.

Mr. Patrick Davison will be the Project Manager (PM) for the TO and will be responsible for the successful completion of the verification project. Mr. Davison will have responsibility for obtaining all of the information needed to plan and execute the VTP, managing the data collected during the test period, overseeing the preparation of the draft Final Report, and providing technical guidance in conjunction with the Technology Panel. Scherger Associates will prepare the VTP and will prepare the Draft Verification Report.

NSF International will provide the laboratory services for the testing program. NSF will be responsible for all quality assurance for the VTP through its QA group. NSF will provide administrative and technical support for review and production of the VTP and the Final Report. NSF will also provide cost tracking support for this VTP. The NSF staff involved in the VTP as members of the TO will be separate from the NSF management and staff that are providing the oversight for the ETV program as members of the VO. NSF will subcontract with TriMatrix Laboratories, Inc. of Grand Rapids, Michigan (TriMatrix) for analyses as noted later in this Test Plan. TriMatrix will follow their QA plan for this work. The NSF QA GROUP or their designee will review the QA and data reports. TriMatrix has passed a preliminary review and audit. The laboratory is familiar with EPA QA requirements and performs many projects to EPA, DOD, and DOE QA specifications.

The responsibilities of the TO include:

- Preparation of the site specific Verification Test Plan;
- Conducting Verification Testing, according to the Verification Test Plan;
- Installation, operation, and maintenance of the Hydro-Kleen unit in accordance with the Vendor's O&M manual(s);
- Controlling access to the area where verification testing is being carried out;
- Maintaining safe conditions at the test site for the health and safety of all personnel involved with verification testing;
- Scheduling and coordinating the activities of all verification testing participants, including establishing a communication network and providing logistical and technical support;
- Resolving any quality concerns that may be encountered and report all findings to the Verification Organization;
- Managing, evaluating, interpreting and reporting on data generated by verification testing;
- Evaluation and reporting on the performance of the technology; and,
- If necessary, document changes in plans for testing and analysis, and notify the Verification Organization of any and all such changes before changes are executed.

The key personnel and contacts for the TO are:

NSF INTERNATIONAL – PROJECT MANAGER
Mr. Patrick Davison
Project Coordinator
(734) 913-5719 email: Davison@nsf.org

NSF INTERNATIONAL – LABORATORY SUPPORT
Hydraulics Laboratory Contact:
Mr. Sal Aridi
Group Leader
(734) 769-8010, Ext. 2298 email: aridi@nsf.org

Chemistry Laboratory Contact:
Dr. Kerri LeVanseler
Technical Manager
(734) 769-8010, Ext. 2367 email: levanseler@nsf.org

NSF INTERNATIONAL - QUALITY ASSURANCE SUPPORT
Ms. Theresa Uscinowicz
QA & Safety Specialist
(734) 769-8010, Ext. 2257 email: uscinowicz@nsf.org

NSF International
789 Dixboro Road
Ann Arbor, Michigan 48105

SCHERGER ASSOCIATES
Mr. Dale Scherger, Consultant, Testing Organization (TO)
(734) 213-8150 email: daleres@aol.com

Scherger Associates
3017 Rumsey Drive
Ann Arbor, MI 48105

2.4 Technology Vendor

The In-Drain Treatment Technology being evaluated is the Hydro-Kleen™ Filtration System manufactured and distributed by Hydro Compliance Management, Inc. (HCM). The vendor will be responsible for supplying the equipment needed for the VTP and will support the TO in ensuring that the equipment is properly installed and operated during the verification test period. Specific responsibilities of the vendor will include:

- Initiate application for ETV testing;
- Provide input to the verification testing objectives to be incorporated into the Verification Test Plan;
- Select the laboratory test site;
- Provide complete ready to operate equipment, and the operations and maintenance (O&M) manual(s) typically provided with the technology (including instructions on installation, start-up, operation and maintenance) for verification testing;
- Provide any existing relevant performance data for the technology if it has been tested/operated at other locations;
- Provide logistical and technical support as required;
- Provide assistance to the Testing Organization on the operation and monitoring of the Technology during the verification testing;
- Review and approve the site-specific Test Plan;
- Review and comment on the Verification Report; and
- Provide funding for verification testing.

The key contact for Hydro Compliance Management, Inc. will be:

Mr. David Woelkers,
Director of Distribution and Regulatory Compliance
(800) 526-9629 email: dwoelkers@HydroCompliance.com

Hydro Compliance Management, Inc.
8741 Main Street, Suite J
Whitmore Lake, Michigan 48189

2.5 ETV TEST SITE

The verification test will be performed at NSF International. The test site address is as follows:

NSF International

789 Dixboro Road

Ann Arbor, Michigan 48105

The Hydraulics Laboratory will be the location of the test setup and operation of the Hydro-Kleen™ Filtration System. This laboratory group will be responsible for record keeping and providing information on activities that may affect the characterization and verification test results. These responsibilities include:

- Provide space and utilities for the test setup
- Provide equipment, piping, pumps, valves, flowmeters, tanks, etc. needed to setup the test and run water to the Hydro-Kleen™ unit
- Install the equipment and wet test the system to ensure the system is operational
- Perform the testing of the equipment in accordance with the Test Plan
- Collect samples and record flow rates for each Phase of testing
- Maintain records and information on the operation of the unit

2.6 TECHNOLOGY PANEL

Representatives from the Technology Panel will provide technical and professional support if needed by the TO during all phases of the verification test period. The Panel will support the Verification Organization as needed during the preparation and review of the Verification Report.

2.7 STAKEHOLDER ADVISORY GROUP

The Source Water Protection Stakeholder Advisory Group will assist the Verification Organization throughout the Verification Test on an as needed basis.

3.0 DESCRIPTION OF THE HYDRO-KLEEN™ FILTRATION SYSTEM

3.1 TECHNOLOGY OVERVIEW

The Hydro-Kleen™ Filtration System is a patented multi-media filtration design that includes sediment containment and overflow protection. The unit is designed for use in catch basins and drain inverts as an in-drain treatment technology. Each unit is manufactured to fit the specific catch basin or drain invert. Units are placed into existing catch basins by removing the grate/cover, inserting the unit into the basin and replacing the cover. As water flows into the unit, the water is directed into a sedimentation chamber, which collects coarse sediment/solids and debris passing through the inlet grate. Water then passes from a transition inlet at the top of the sedimentation chamber into the filtration chamber. The first media, Sorb-44, catches hydrocarbon contamination through absorption onto a hydrophobic pulp material. The second media is an activated carbon (AC-10), which polishes any remaining hydrocarbons in the water and may remove a variety of organically bound metals and other contaminants in the runoff. Water then passes through the bottom into the catch basin.

Units are designed to trap contaminants contained in water flowing through the unit during storm events, while providing overflow protection to ensure sufficient flow can pass through the catch basin or drain inlet during large storm events. The unit is designed to by-pass larger flows in order to eliminate flooding from backup during heavy wet weather events. Figure 3-1 shows the Hydro-Kleen™ Filtration System.

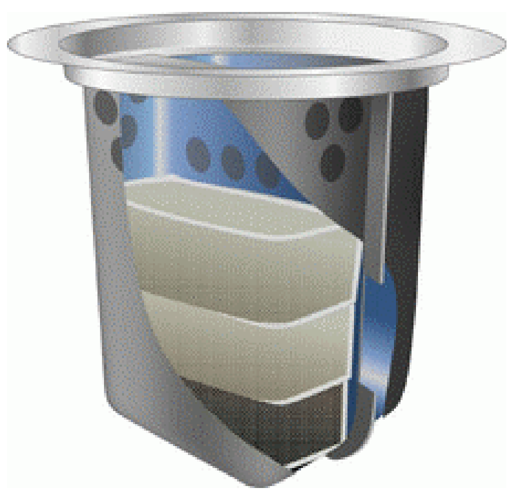

Figure 3-1: Rendition of the Hydro-Kleen™ Filtration System

The unit must be maintained on a regular schedule to prevent saturation of the filter media by contaminants and blockage from sediment and debris buildup. Maintenance is accomplished by vacuuming sediment/debris from the sedimentation chamber and replacing the filters. The manufacturer recommends filters be changed every 4 to 6 months dependent upon location and sediment loads. Additional maintenance may be needed depending on the location and season. The manufacturer recommends a clean out after heavy leaf fall.

3.2 TEST UNIT SPECIFICATIONS AND TEST SETUP DESCRIPTION

The unit that will be used for the Verification Test will be a full size, commercially sold unit. The unit will be a rectangular unit having the standard size dimensions of 17 inches (length) by 17 inches (width) by 24 inches (deep) that can be purchased from the manufacturer. In normal business practice, the units are sized to fit the catch basin or drain inlet for a specific application. A stainless steel collar is sized to fit the specific opening in the drain inlet or the catch basin and is attached to the unit. The unit that will be used in the Verification Test will have a collar that will fit a standard 24 inches X 24 inches opening. Figures 3-2, 3-3 and 3-4 present the typical size and installation of the unit and provide more detail on the location of various features within the treatment unit.

Figure 3-2: Hydro-Kleen™ Filtration System Components

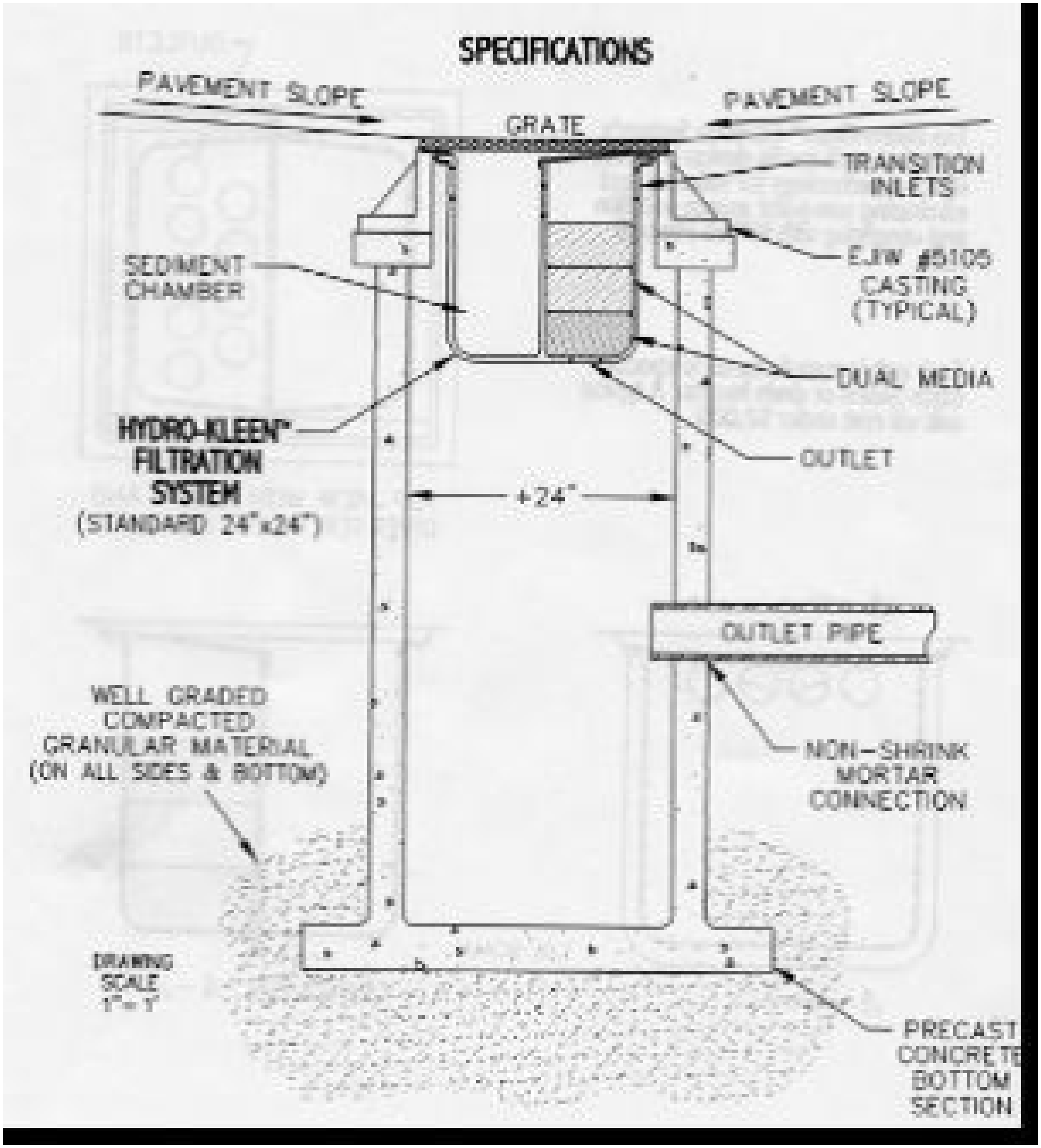

Figure 3-3: Section and Top View of Hydro-Kleen™ Filtration System

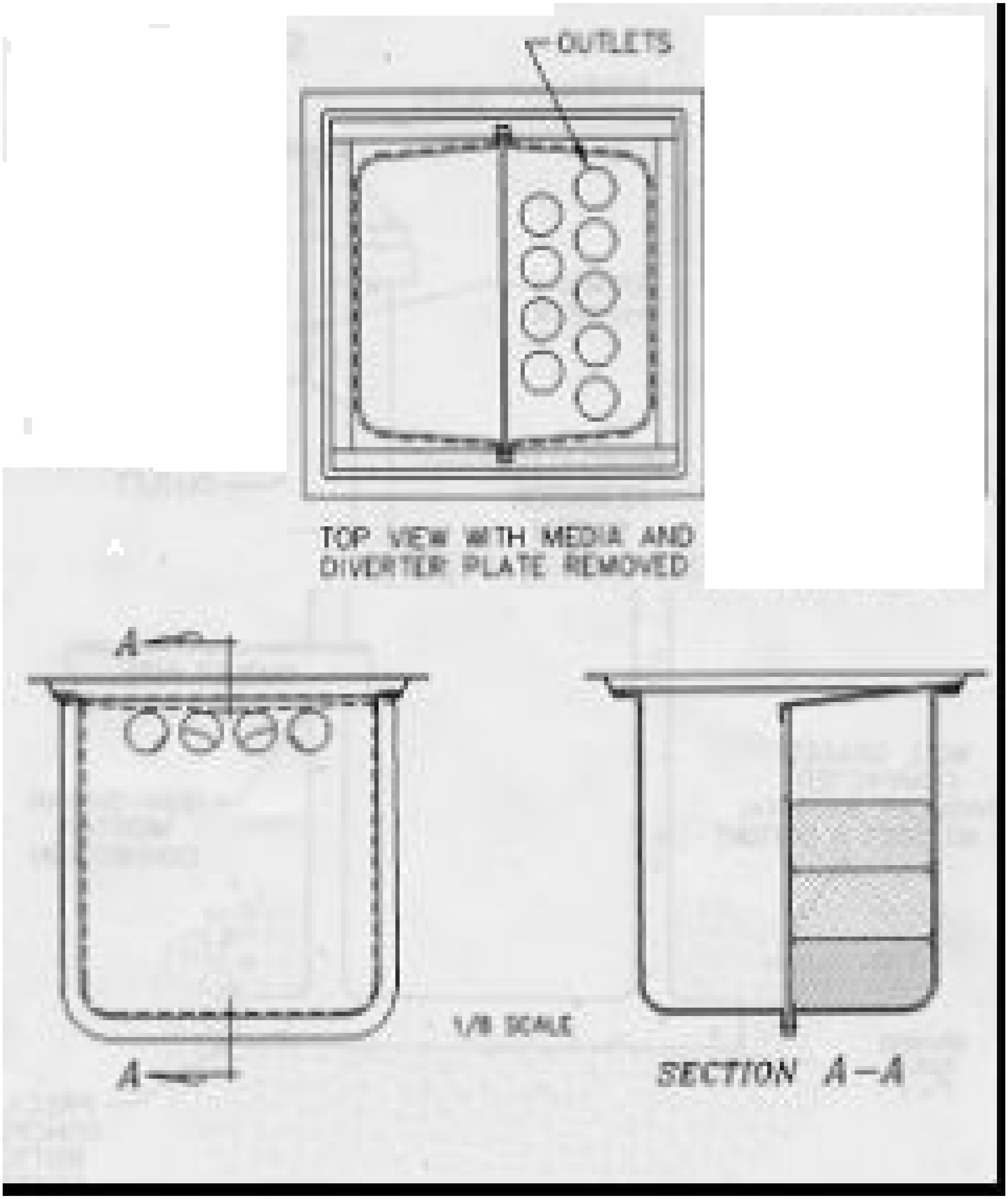

Figure 3-4: Section and Top View of Hydro-Kleen™ Filtration System

The Verification Test will be performed at the NSF International, Inc. Hydraulics laboratory location in Ann Arbor, Michigan. The NSF Hydraulics Laboratory is set up to handle testing of this type with physical facilities that includes a water supply up to 100 gallons per minute, tanks, mixers, and pumps to store and feed the synthetic water, and all other associated piping, controls and related equipment. The Hydro-Kleen™ Filtration System is a passive unit that does not require any utility connections to operate. Therefore, there will be no electrical or water requirements needed for operation of the unit. There will be water and electrical needs for the laboratory to supply the synthetic test water to the unit, operate pumps, mixers, and sampling equipment, etc. However, none of these requirements would be needed in a field application. There will be no special permitting needed to operate the unit or the test facility equipment for this verification.

The synthetic wastewater described later in this Test Plan will contain hydrocarbons (gasoline, diesel fuel, motor oil) that could be discharged to the city sewer system if the unit does not remove these contaminants during the test. The levels of these contaminants in the synthetic water are within the discharge limits of the city system, based on conversations with the City of Ann Arbor Wastewater Treatment Plant. Therefore, there will be no special requirements for disposal of the treated water from the unit. The solids that accumulate and organics that are trapped on the absorbents will be solid waste that require disposal during the test. Based on the manufacturers data and general information regarding the contaminants that most likely will be removed and present in the residues, these solids wastes should be acceptable for disposal in a standard municipal landfill. The residues will be tested prior to disposal to ensure they are not regulated materials that require special disposal.

The unit will be installed at the NSF Hydraulics Laboratory so that water will enter and exit the unit by gravity as would occur in a typical field installation. Figure 3-5 shows a schematic process flow diagram for the test setup at the laboratory. Detailed information on the test setup and operation of the system will be presented in Section 4 – Experimental Design.

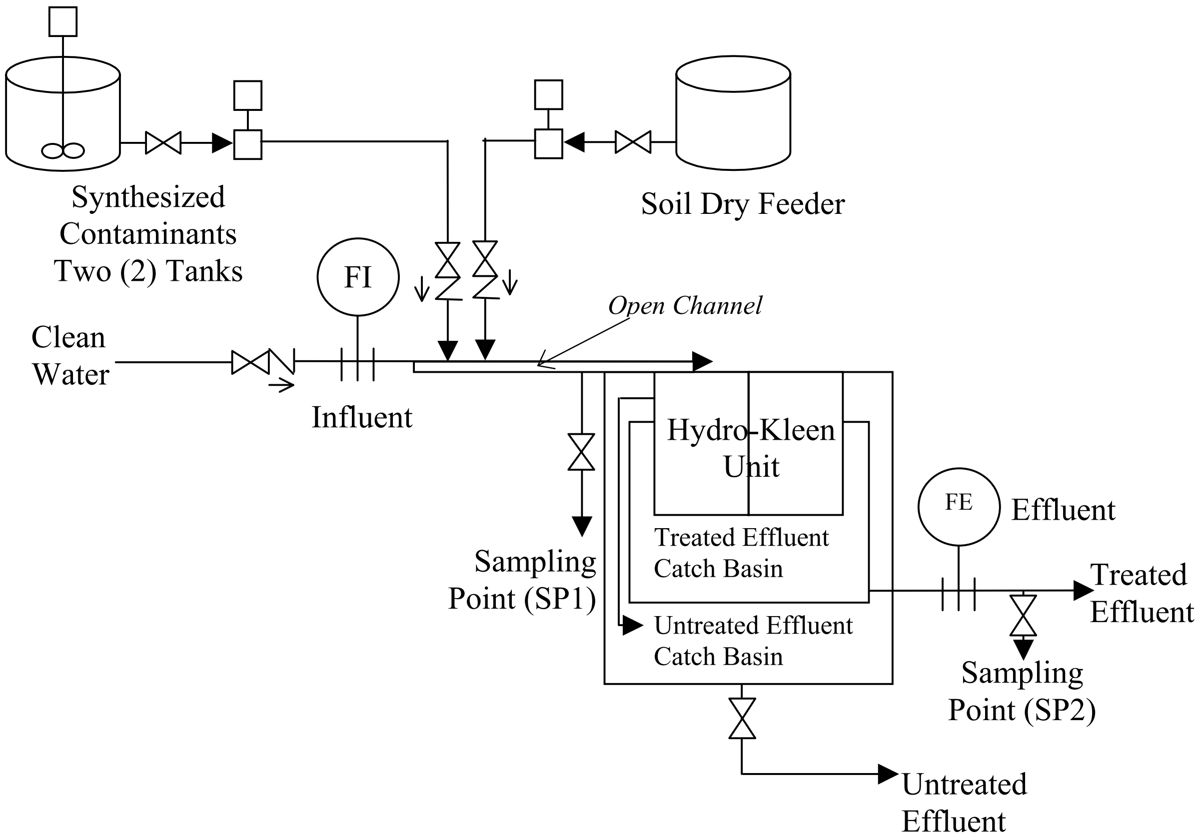

Figure 3-5: Process Schematic of Test System Setup

3.3 HYDRO-KLEEN™ FILTRATION SYSTEM CAPABILITIES AND CLAIMS

3.3.1 SYSTEM CAPABILITY

The design of the unit incorporates both a chamber for the collection of solids (sediment, debris, soil, etc.) and absorbent filled pillows to absorb hydrocarbon materials. This design is based on providing a unit that will remove both settleable solids and hydrocarbons (with associated constituents) from typical stormwater runoff. The unit is designed for application in typical stormwater collection systems that have inlet drains and catch basins. The advantages of the unit are that it has design features to remove both solids and hydrocarbons, and is designed for simple installation in catch basins and drain inlets. The vendor claims it will typically treat all of the stormwater entering the unit up to flows of approximately 50 gpm. Flow rates above this level will result in stormwater bypassing the treatment unit and discharge directly to the collection system. The unit has the advantage of being fed by gravity from the drainage area and not being installed in the actual pipe in the collection system. The unit is designed to bypass flow rates that are larger than the flow rate that can enter the catch basin or drain inlet through the grate. Therefore, head loss and flow restrictions will not cause collection system backups. However, if flow rates through the inlet do exceed the bypass capacity, ponding and backup on the surface will occur. Solids and hydrocarbon removal will be limited to the capacity of the unit to hold these pollutants and if the unit is filled with solids or the absorbents reach capacity, no further removal will occur. Therefore, cleanout and absorbent replacement are important to the successful long-term operation of the unit. The unit has the advantage that there are no utility requirements, no electronic or mechanical control systems to fail, and should be easy to install.

This Test Plan is designed to meet the basic requirements of the Generic Protocol for In-Drain Treatment Technologies and will focus on the treatment capability of the unit to remove sediment and hydrocarbons from the test synthetic wastewater. The experimental design and sampling and analysis plan presented in later sections provide details on the test protocol and the constituents targeted for this verification.

The vendor makes certain claims and describes the technology and its advantages as presented below. Further, the vendor has provided test data from other evaluation programs conducted on this unit and presents basic operation and maintenance guidance in its literature. The data provided by Hydro Compliance and information on installation and maintenance are provided in Appendix A.

3.3.2 VENDOR CLAIMS AND INFORMATION

3.3.2.1 Application

Hydro– Kleen™ Filter Systems are an effective technology available for use with stormwater catch basins or drains to trap sediments and substantially reduce contaminant levels from stormwater and other non-point source runoff. These multi-media filtration systems contain design features which address concerns dealing with sedimentation and water flow issues while effectively filtering out hydrocarbons and other toxins. When utilized with a regular maintenance program Hydro-Kleen™ unit is an effective Best Management Practice (BMP) to assist governments and private business in meeting NPDES and other water runoff requirements for protecting surface water quality.

The Hydro-Kleen™ unit does not require expensive installation and labor costs as it can fit into most existing catch basins. Each unit is manufactured to fit the catch basin or drain into which it is inserted. The units are placed into existing catch basins by removing the cover or grate, inserting the unit into the basin, and replacing the cover (See installation information in Appendix A).

The unit must be maintained on a regular schedule to prevent saturation of the filter media by contaminants and blockage from sedimentation and debris buildup. Maintenance is simple and can be accomplished by merely removing the cover, vacuuming debris from the sedimentation chamber, and replacing the filters. The maintenance of each unit should take only minutes and can be done with minimal instruction. A typical recommended change out of the filters would be every 4 to 6 months. Sedimentation maintenance may be needed more often depending on the location and season. A clean out after heavy leaf fall is recommended.

Disposal of the media in a typical drain system, such as for use with parking lots, outdoor maintenance areas, etc., can be accomplished through placements into Class II landfills since the filter media is non-leaching. Applications for other uses may require disposal with a license facility depending on the contaminant load.

3.3.2.2 Data

Laboratory test results of the media have been provided by Hydro Compliance and show reduction of hydrocarbons and other contaminants to non-detect levels (See Appendix A). A properly maintained unit will achieve substantial reduction of contaminants into the surface water. The units are designed to trap contaminants contained in maintenance areas, parking lots, gasoline stations, truck stops and the "first flush" from storm events while allowing overflow protection to ensure sufficient flow to prevent flooding from back up during heavy wet weather events. Street units strategically placed downstream from sites which contain higher contaminant levels, such as gas stations, parking lots and industrial sites, give municipalities and businesses an effective tool for reducing non-point source pollutants in their systems.

3.4 PERFORMANCE MEASURES FOR THE VERIFICATION TEST

The performance capabilities of the Hydro-Kleen™ Filtration System unit will be assessed both quantitatively and qualitatively. Sampling and analysis of the influent, effluent, and residues will provide data to determine the treatment efficiency of the unit with quantitative data. Recording of visual observations, operational issues and maintenance requirements will provide a basis for qualitatively assessing the unit's performance. The entire Test Plan, including the Experimental Design, Sampling and Analysis Plan, and Quality Assurance Project Plan, is focused on obtaining performance-based data that will serve as the foundation of the Verification Report and the verification statement.

3.4.1 CONTAMINANT SELECTION AND MONITORING FOR PERFORMANCE

The Hydro-Kleen™ unit as described previously is designed to remove solids and organics that are present in stormwater runoff. Based on the unit's capabilities a list of targeted contaminants that will be monitored for removal by the unit has been selected. The targeted list is as follows:

Targeted Contaminant List

- Total Petroleum Hydrocarbons (TPH)
- Total Suspended Solids (TSS)
- Chemical Oxygen Demand (COD) - a common organic content indicator parameter
- Total Organic Carbon (TOC)
- Benzene, Ethylbenzene Toluene, Xylene (BETX)
- Methyl Tertiary Butyl Ether (MTBE)

In addition to the primary target list there are additional parameters or organic indicator tests that can measure performance of the unit. Oil and Grease is a general organic compound test for petroleum-based materials. The test has been used for many years but is not as accurate and precise as other indicators. Oil and Grease will be analyzed but on a less frequent basis. The Hydro-Kleen™ unit will generally not remove inorganic soluble metals. However if heavy metals are present as organic bound material or are adsorbed on the solids, then some reduction can occur. While metals reduction might be expected in field applications of this unit, where vehicle washing of road grime may have these types of metals present, it is difficult to develop synthetic test water with these types of metal compounds. Therefore, the level of metals present in the synthetic water will be low and metals measurements will be on a less frequent basis than the targeted contaminants. The additional contaminate list is as follows:

Additional Contaminant List

- Oil and Grease (O&G)
- Metals (Al, Cd, Cr, Cu, Fe, Pb, Zn)

The Generic Protocol provides an additional list of possible contaminants that includes nutrients, surfactants, and total phenol. The protocol indicates that these contaminants are potential contaminants of concern and that they must be analyzed as part of the test program. These secondary parameters will be monitored in a few selected samples in order to provide the "background" information. The Hydro-Kleen™ unit vendor specifically states that they make no claims regarding nutrient reduction and do not expect to impact nutrient levels in the stormwater.

Secondary contaminants – not performance parameters

- Total Phosphorus
- Total Kjeldahl Nitrogen
- Ammonia Nitrogen
- Nitrate Nitrogen
- Surfactants (MBAS)
- Total Phenol

All of the above constituents will be measured in influent and effluent samples in accordance with the experimental design and the Sampling and Analysis Plan. The results will provide data for determining the performance capability of the unit to remove targeted contaminants and provide data on the additional and secondary contaminants as well. All of these data will be reported in the Verification Report as part of the quantitative performance measurements.

3.4.2 SYSTEM COMPONENT OPERATION AND MAINTENANCE PERFORMANCE

The overall system performance will be measured both quantitatively and qualitatively. Quantitative measurements will include determination of the range of hydraulic flow conditions that can be handled by the unit. The hydraulic capacity of the unit will be determined by measuring the hydraulic flow rate in volume of water treated and flow rate handled. The experimental design includes both hydraulic loading tests and loading of contaminants to the unit. The absorption medium will be stressed to exhaustion and spike loads will be charged to the unit at high flow rates. Mass removal of contaminants will be determined.

Qualitative measures will be assessed by observations of and experience with the unit during the setup and testing phases. Records will be maintained on the ease and time of installation, the time and ease of maintenance for cleanout and absorption medium replacement, and other operating observations. The unit is a simple design with no controls, instrumentation, alarms, or other mechanical or electrical devices that will require operation. The unit will be monitored for solids or debris buildup, clogging of entry paths, and other related operational issues. The Operations and Maintenance Manual provided by Hydro Compliance will be reviewed for its specificity and completeness. These observations, experiences, records and review will be the basis for evaluating the system performance in terms of operation and maintenance.

3.4.3 QUANTIFICATION OF RESIDUALS

Testing the Hydro-Kleen™ device will create residual material, such as removed contaminants, sediments, and spent filter media. The quantity of residual materials requiring disposal is a factor in performance measurements. Refer to Section 4.5 of this VTP for a discussion of how residual materials will be quantified during the tests.

4.0 EXPERIMENTAL DESIGN

4.1 INTRODUCTION

The experimental design described in this Test Plan is designed to obtain quantitative and qualitative data on the performance capabilities of the test equipment. The data collected will serve as the basis for determining the effectiveness of the treatment unit to reduce constituent loads in the influent synthetic wastewater. The data collected in accordance with the experimental design and Sampling and Analysis Plan will be presented in the Verification Report and serve as the basis for the Verification Statement for this technology.

The experimental design follows the methods and procedures defined in the Generic Protocol for In-Drain Treatment Technologies, April 2001(GP). The design incorporates all of the elements described in the GP and includes all of the phases of testing prescribed. There are three deviations or exceptions from the GP as understood by the Testing Organization. These deviations are: 1) the measurement of head loss is not directly applicable due to the design of the Hydro-Kleen™ Filtration System; 2) operation of the unit for 24 hour periods during the capacity study is modified to 16 hour operation due to lab schedule; 3) the synthetic wastewater concentrations have changed from the original protocol due to a problem with the original mixture specified in the GP. Each of these changes or modifications from the GP will be discussed in the sections below.

The verification test will be a controlled test. The testing will be performed on a full-scale unit set up in the NSF International laboratory. The NSF laboratory is a physical testing laboratory with space, tanks, piping, utilities, etc., to perform large scale (50-100 gpm) testing of this type. A synthetic wastewater will be used for the testing. The synthetic wastewater will be made as described later in this section and dosed to the unit as prescribed in the GP.

4.2 TEST SITE AND SETUP

The test site will be the NSF Hydraulics Laboratory at the main offices in Ann Arbor, Michigan. The Hydraulics Laboratory is setup to handle large flow testing and full-scale unit testing, as part of the NSF certification and testing programs. The facility has space to setup several large tanks and piping to convey the wastewater to the full-scale test unit. The lab can supply up to 100 gpm of city water as a main feed during the testing and has ample electrical service to run all pumps, controllers, samplers, and associated equipment.

As stated earlier, the Hydro-Kleen™ Filtration System unit used for the verification test will be a full size commercially available unit. It will be the standard size, 24 inches by 24 inches catch basin insert unit, which is sold for this in-drain application. The unit will be placed in a stand that simulates a catch basin. Influent to the unit will be by gravity in a manner similar to a field application. Effluent from the unit will flow by gravity out of the bottom of the test stand in the same manner that the flow exits the unit in the field, which is through the bottom of the catch basin and into the collection system.

Figure 3-5 shows the process flow diagram and equipment configuration for the test setup. City water will serve as the main water feed with a maximum flow rate of up to 100 gallons per minute (gpm). A flow control valve will control the flow. The flow rate of the water will be measured using a standard "paddle wheel" style flow meter that will show flow rate (gpm) and will totalize the volume processed (gallons). The water will enter an open channel that will be approximately 5 inches wide and 5 inches high. The water will flow by gravity to the test stand holding the Hydro-Kleen™ unit. The synthetic wastewater will flow through the channel by gravity, drop into the inlet area (creating a waterfall for mixing and sampling), and then enter the inlet grate on the top of the unit in a similar manner to the standard way that wash water and stormwater enters a catch basin.

Synthetic wastewater will be made by adding a mixture of gasoline, diesel fuel, motor oil, sand, clay, etc. to the city water. Two tanks will be used to hold stock solutions for these materials. One tank will hold a mixture of the petroleum products (motor oil, gasoline, diesel fuel, brake fluid) and the other tank will hold the mixture of water-soluble materials (anti-freeze, surfactants, detergent, windshield washing fluid, etc.). A dry feeder will be used to feed a mixture of clay, topsoil, and sand to the city water. Initial tests in the lab found that the sand could not be kept in suspension even in a stirred sample bottle. Therefore, the dry feeder will be used to feed the solids into the open channel just upstream of the petroleum based and water soluble stock solution addition points.

The chemical stock solutions will be pumped by chemical metering pumps directly into the open channel carrying the city water and solids. The chemical meter pumps will provide fine control on pumping rates. Injection rates will be monitored using flow meters in each line. A second check on the feed rates of the stock solutions will be through daily recording of the levels in the stock tanks at both the beginning and end of each run. Checks may be done more frequently as needed. The stock solutions will be injected just upstream of a drop in the channel creating a waterfall to encourage complete mixing of the solids, petroleum products and water soluble materials. The sampling location for the influent will be at this "waterfall" location, just before the influent flows over the grating and into the unit. The sampling location provides the capability of immersing the sample collection bottle(s) directly into the mixed water, thus helping to ensure that a representative sample of the entire flow is collected. All sampling will be performed manually for all test sequences. This eliminates the concern regarding the collection of representative solids and hydrocarbon samples when using automatic sampling equipment.

The synthetic wastewater will enter the treatment unit through the standard inlet grating, flow through the sediment collection section, and pass over/through the absorbent materials. The treated water will exit the bottom of the unit entering the bottom of the test stand (a simulated catch basin) and exit by an attached pipe. A flow meter will be located in the treated water discharge pipe that will monitor flow rate and total volume. A sampling port will be located in the effluent pipe that will be set up for collection of manual grab samples. All sampling will be performed manually for all test sequences. The test stand will include a special design to separate water that passes through the treatment unit (exit the bottom of the unit) from any water that bypasses the unit through the overflow bypass system. The bypass outlets on the side of the unit near the top will flow to a separate collection pipe that will carry the bypass water around the treated water effluent pipe. The bypass water will recombine with the treated water downstream of the treated effluent sampling and flow monitoring locations. Bypass flow rate and volume will be determined by comparing the influent flow rate and volume to the treated water flow and volume. The difference between these flows and volumes will be the rate and amount of water exiting via the bypass system.

4.3 TEST PHASES – HYDRAULIC LOADING

The unit will be tested under varying hydraulic load conditions to simulate typical conditions found in wash water applications (i.e., catch basins and drain inlets in streets, parking lots, etc.) and during stormwater flows. The primary operational characteristics will be tested to determine:

- Performance under intermittent flow conditions (Phase I);
- Performance under different hydraulic loadings, including peak flow (Phase II);
- Performance at different contaminant loadings (Phase III); and
- Capacity of the unit to contain contaminants (Phase IV).

The testing will be done in four phases that will include conditions designed to test all of the above-mentioned operating scenarios. The Phases described below follow the same Phases that are discussed in the GP. The actual order in which this testing is accomplished may change, but all four phases will be completed.

4.3.1 PHASE I - PERFORMANCE UNDER INTERMITTENT FLOW CONDITIONS

In Phase I the system will be operated intermittently to simulate actual in-drain treatment applications during intermittent loadings at flow rates that are typical average flow rates over a period of time. The Hydro-Kleen™ unit is designed to treat flow rates of up to approximately 50 gpm before any water is bypassed through the overflows. A more typical average flow rate at a catch basin or drain inlet is expected to be in the 5-25 gpm range. A flow rate of approximately 15 gpm will be used for the Phase I five day test.

The intermittent tests will be run for a five (5) day period. Each twenty-four hour period will consist of an eight (8) hour ON cycle, followed by a sixteen (16) hour OFF cycle. During the 8 hour ON cycle, the unit will receive flow for 15 minutes, followed by a 15-minute period with no flow. The result will be 16 flow periods in the 8 hour ON cycle (two 15 minute flow periods per hour for 8 hours). The flow will be constant during the dosing periods at a flow rate of approximately 15 gpm.

The well-mixed stock solution tanks will be filled prior to the test and the volume recorded. The chemical feed pumps will be calibrated prior to the start of the testing and set to the appropriate feed rates. The test will be started by opening the flow control valve for the main water supply and turning on the chemical feed pumps. Flow rates will be checked and recorded. The flow will be maintained for a 15-minute period and then the water supply and chemical feed pumps turned off for 15 minutes. This cycle will be repeated for the 8 hour ON test period. The entire cycle will be repeated for five days.

Samples of both the influent and the effluent will be collected by manual grab samples. Samples will only be collected of the influent and effluent when flow is being sent to the unit. Some parameters being monitored will be composites over the operating day, whereas volatiles (BETX and MTBE) and O&G need to be grab samples. Samples for TSS and TPH analysis will be collected manually on a flow-weighted basis (every 800 gallons of flow), and the individual grabs will be combined by the laboratory (each bottle extracted and extracts added together or for solids all bottles filtered) to generate a flow-weighted composite sample. The other parameters, such as metals, nutrients, COD, TOC, T-Phenol, and surfactants will be sampled by collecting individual grab samples of known volume after every 800 gallons of flow to the unit. The grab samples will be combined into one large container to form a flow-weighted composite sample. The container will be mixed and the sample poured off into the appropriate container for the various analyses. Grab samples for BETX, MTBE and O&G will be collected one time during each 8-hour ON cycle from both the influent and effluent sampling locations. Table 5-1 in the Sampling and Analysis Plan provides a summary of all sampling and analysis schedules for verification test.

On the first and third day of intermittent cycling, a special sampling program will include one-hour composites (8 total) for TSS and COD. Grab samples will be collected during each of the two 15 minute flow cycles each hour and composited into a single sample for analysis. On these two days, the eight-hour flow-weighted composite for TSS and COD (described above) will not be collected and analyzed. The TSS analysis will follow the same special procedure. The entire volume of sample from the grab samples will be filtered for the solids test. This will ensure that the heavier particles (sand) are contained in the sample being filtered and not left in the sample bottle. This procedure is described further in Section 5, Sampling and Analysis Plan.

Flow rates will be monitored throughout the test period on a minimum of a once per hour basis. Cumulative volumes processed during the test will be monitored based on the flow rates and the totalizing flow meters. All flows (influent, stock solution feeds, effluent) will be recorded in a permanent logbook. The logbook will also be used to record observations made during the test runs. Observations will include a physical description of the effluent water with respect to color, oil sheen, etc. The unit will be observed for any evidence of clogging, change in operating head or head loss, flow patterns, or any evidence of bypass or short-circuiting.

The GP calls for the measurement of head loss as part of the monitoring of flow conditions in the unit. Head loss is a concern for in-drain units that are inserted into the drain and have no bypass or ability to overflow. If head loss is high, then the drainage system capacity is limited and flooding can occur on surface areas. The Hydro-Kleen™ unit, however, is designed to bypass any flow that does not pass through the absorption media. The unit has a bypass design capacity that is greater than the typical inlet grate. By designing the unit bypass capacity larger than the inlet grate capacity, it is ensured that flooding cannot occur due to a backup or plugging of the absorption media. The standard size unit (24 inch X 24 inch) has 32 – 2 3/8 inch diameter holes for the overflow. The vendor supplied calculations showing the typical flow rate for an East Jordan Iron Works inlet grate and the Hydro-Kleen™ unit are presented in Appendix B.

Given that the unit is fed by gravity, is open at the top, and has an overflow capacity greater than the inlet, it is not possible to measure head loss on the influent stream to the unit. An approximation of the depth of water over the filter media in the treatment chamber will be monitored by noting whether water is bypassing the treatment media, and reported as an estimate of the head loss through the media. This head loss, however, only impacts the capacity of the unit to treat water and does not impact the concern regarding flooded conditions.

As described in the test setup section (Section 4.2), the unit will be fed by gravity in a similar manner to the flow conditions expected in the field applications. The flow will enter the top of the unit from an open channel and flow by gravity into the unit. All effluent will flow out of the unit by gravity and exit via the open channel leaving the test stand. The intermittent flow cycles will simulate conditions that can be expected during small rain events or during flows from a commercial/industrial operation that might reach a storm drain inlet or catch basin.

The vendor claims that the capacity of the unit for petroleum hydrocarbons is approximately the equivalent of 5 gallons of diesel fuel. At an average density of 7.3 lbs/gal for diesel fuel, this would represent about 37 pounds of hydrocarbons. The synthetic mix is expected to have approximately 25 mg/L of total petroleum hydrocarbons. Therefore, the unit should be able to treat approximately 175,000 gallons of flow (assuming 100% removal). Each eight-hour cycle will have 240 minutes of flow at 15 gpm to yield 3600 gallons per day or 18,000 gallons for the five-day period. Additionally, the unit has a relatively large capacity (17 inches X 8 3/4 inches X 12 inch useable depth = about 1 cubic foot) for holding sediment (settled solids). The wastewater will have approximately 150 mg/L of sand. Assuming 100% removal from a flow of 18,000 gallons and a 90 pounds per cubic foot bulk density, the sand would occupy 0.25 cubic feet. Therefore, sediment cleanout is not anticipated until the Phase I test is completed. The vendor has indicated that the unit will most likely reach capacity for this synthetic water due to blinding of the filter media by the fine clay and soils. The estimate is that the unit will handle in the range of 40-80,000 gallons of water containing 300 mg/L of solids. Based on these initial estimates, it is not expected that the unit will require maintenance or changing of the absorbents during the Phase I test period due to organic loading.

At the end of the Phase I period, the unit will be inspected to determine the condition of the sediment chamber and the absorbents. Observation of water depth over the filter media during the test run will provide an indication if the media is beginning to blind or plug. If the media and sediment chamber are in good operating condition, the media will be removed, drained, weighed and returned to the unit for the capacity study. If the sediment chamber appears to be filling quicker than expected or the media is beginning to plug as indicated by water draining through the bypass holes during the low-flow testing, the unit will be cleaned and the absorbent material will be replaced as described in Section 4.5.

4.3.2 PHASE II – DETERMINATION OF THE CAPACITY OF THE UNIT

The objective of the Phase II testing will be to run the unit to "exhaustion" with respect to the capacity of the absorbent material to remove suspended solids and/or organic materials. During this phase of testing, the unit will be operated under continuous flow conditions for 16 hours a day until the unit plugs with solids or the contaminant absorption capacity is exceeded. The GP calls for continuous operation during the capacity test. However, the test set up is based on manual operation and observation. The high water flow rates and manual operation require that a technician be present at all times to ensure water overflows or other problems do not occur. The NSF lab normally operates on an 8-hour day but will extend to 16-hour operation for this test. It is not practical to operate twenty-four hours per day. Further, it would be highly unusual for an in-drain unit to flow at near maximum flow continuously until exhaustion occurred. Therefore, operating on a 16-hour basis should not have any impact on the overall capacity results or the applicability to the real world.

If the unit is in good operating condition after Phase I, the loading placed on the unit sediment chamber and filter media will be incorporated into the capacity test as provided for in the GP. The total loading from Phase I will be added to Phase II data to calculate total capacity. If the unit has shown signs of plugging or reaching capacity in the Phase I test, then the unit will be cleaned and fresh absorbent will be placed in the unit prior to the start of the test. The flow rate for this test will be set at 40 gpm, which is approximately 80% of the maximum rated flow capacity of 50 gpm.

The vendor claims that the capacity of the unit for petroleum hydrocarbons is approximately the equivalent of 5 gallons of diesel fuel. At an average density of 7.3 lbs/gal for diesel fuel, this would represent about 37 pounds of hydrocarbons. The synthetic mix for this portion of the test is expected to have approximately 25 mg/L of total petroleum hydrocarbons. Therefore, the unit should be able to treat approximately 175,000 gallons of flow (assuming 100% removal). At a flow rate of 40 gpm, it will take approximately 70-75 hours to reach the capacity of the unit. Based on vendor information, it is not expected that contaminant (hydrocarbon) capacity of the absorbent will be exceeded before the loading of suspended solids begins to plug the filter media and causes the unit to overflow through the bypass openings. The filter media is expected to "blind off" due to the presence of the small clay particles and high solids loading. It is not known how much loading the unit can receive before the capacity is exceeded. If the unit capacity has not been exceeded in the first 16-hour run (about 37,000 gallons of water), the unit will be operated for a second 16 -hour period on day two or until the solids capacity is reached. If after the second 16-hour period indicates exhaustion has not been achieved, then the unit will be started again and will continue to be dosed on a 16-hour run schedule until the maximum absorption capacity is reached.

Samples will be collected on a grab sample basis. Samples from the influent and effluent will be collected at the start of the test and after approximately each 10,000 gallons of influent flow, and analyzed for the primary constituents (TSS, COD). Samples of the effluent for TOC, TPH, O&G, BETX/MTBE, surfactants, total phenols, and metals will be collected at the start of the test and after approximately 20,000 gallons treated and at the end of the 16-hour day (approximately 38,400 gallons treated). Influent samples will be collected at the start and end of the test. Samples of the influent and effluent for nutrients (TKN, Ammonia, T-P) will be collected at the beginning and end of each run. During the second 16-hour test period (day two), the same sampling schedule will be maintained. Samples will only be analyzed for water volumes up to the time that unit begins to blind off and cannot pass the all of the influent through the filter/absorption media. If the capacity of the unit is found to be larger than 75,000 gallons (two 16-hour feed days), samples will continue to be collected until the capacity is achieved. Samples collected at the 20,000 and 60,000-gallon volumes will not be analyzed, and samples collected later in the test run will be run for the same parameter list.

Flow rates will be monitored throughout the test period on a minimum of a once per hour basis. Cumulative volumes processed during the test will be monitored based on the flow rates. All flows (influent, stock solution feeds, effluent) will be recorded in a permanent logbook. The logbook will also be used to record observations made during the test runs. The water depth over the filter media will be monitored and recorded. Increasing depth at the set flow will be an indication that plugging is starting to occur. When the media begin to plug, the water depth will increase and eventually the wastewater will begin to exit through the bypass. At that time, the unit will be assumed to have reached capacity. Observations will include physical description of the effluent water with respect to color, oil sheen, etc.

At the end of the Phase II test, the unit will be cleaned and the absorbent material will be replaced as described in Section 4.5.

4.3.3 PHASE III PERFORMANCE UNDER VARIED HYDRAULIC AND CONCENTRATION CONDITIONS

This phase of testing will focus on determining the unit's hydraulic capacity and how well it handles spike loads of constituents. Phase III will have three distinct parts.

4.3.3.1 Part 1 Hydraulic Capacity with Clean Water

The vendor has stated the Hydro-Kleen™ unit has a rated capacity of 50 gpm for treating water. Flows above 50 gpm are bypassed through the bypass openings in the top of the unit. In order to confirm the rated treatment capacity the unit will be challenged with increasing flow rates using clean water in the Part I test.

The test will start with a clean unit containing fresh absorbent. Only the clean water line will be used for this test. Flow will start at 30 gpm of fresh water for a period of 15 minutes (the unit holds approximately 30 gallons of water, so this will provide about 15 volume changes). After 15 minutes, the flow will be increased to 40 gpm for a period of 15 minutes. Flow will continue to be increased by an additional 10 gpm (50, 60, 70, etc.) in 15-minute increments until flow begins through the bypass holes. The maximum flow rate achieved, before bypass and after bypass occurs, will be recorded in the logbook. After achieving the maximum treated rate, the flow will continue to be increased to challenge the bypass system. Flow will continue to be increased until either the bypass is at capacity and the unit begins to flood or until the maximum available fresh water rate of approximately 100 gpm is reached. All flow rates and operating observations will be recorded in the logbook along with any physical observations regarding the unit response during the test.

As discussed in Section 4.3.1, the GP calls for the measurement of head loss during several Phases of testing. The design of this unit however does not lend itself to head loss determination, and head loss in the unit itself is not a cause for concern with respect to flooding. There will be no head loss due to the unit on the entry line, as the water will flow by gravity into the unit. It is not expected that the unit will actually go to bypass at any time during this test. The unit capacity for overflow described earlier is much higher than the maximum flow rate of water available to the laboratory. Using the entire water supply line the maximum amount of fresh water is about 100 gpm. Observations of the water elevation at various flows will be made so that estimates of media head loss can be made. The overflow will be monitored and water height at various bypass flow rates will be recorded.

4.3.3.2 Part 2 Hydraulic Throughput with Wastewater

The Part 2 testing will follow the same approach as the Part 1 testing except that the synthetic wastewater will be used as the influent water. In this part, the chemical feed pumps and dry feeder will be used to add the stock solutions to the fresh water. At each increase in flow rate, the pumps and feeder will be increased in rate in ratio to the fresh water feed to maintain a constant concentration of constituents in the synthetic wastewater.

The test will be conducted after the Part 1 test and will use the same filter media that was used for the Part 1 test. Flow will start at 30 gpm for a period of 15 minutes (the unit holds approximately 30 gallons of water, so this will provide about 15 volume changes). After 15 minutes, the flow will be increased to 40 gpm for a period of 15 minutes. Flow will continue to be increased by an additional 10 gpm (50, 60, 70, etc.) in 15-minute increments until flow begins through the bypass holes. The maximum flow rate achieved before bypass and after bypass begins will be recorded in the logbook. After achieving the maximum treated rate, the flow will continue to be increased to challenge the bypass system. Flow will continue to be increased until either, the bypass is at capacity and the unit begins to flood, or until the maximum available fresh water rate of approximately 100 gpm is reached. All flow rates and operating observations will be recorded in the logbook along with any physical observations regarding the unit response during the test.

Grab samples of the influent and effluent will be collected at each flow rate condition (30, 40, 50 60 gpm, etc.) until the unit floods or the maximum available feed water capacity is reached. All samples will be analyzed for TSS and COD. Two sets of influent and effluent samples will be collected for TPH, TOC, BTEX, and O&G analysis. One set will be collected at the 40 gpm rate and a second sample(s) will be collected at the maximum rate achieved before flooding as determined in Part 1 or at the maximum rate achieved. It should be noted that the test system is designed to separate the water that receives treatment from the bypass water. The two streams are combined downstream of the effluent sampling point. This design allows collection of treated water samples separate from the bypass flow. Thus, the effluent data will be direct measurements of the treatment efficiency of the unit under these stress conditions without having to back calculate the influence of the bypassed water. Any water bypassed will normally pass through at the same concentration as the influent water.

During this part as in all test runs, all flow rates and operating observations will be recorded in the logbook, along with any physical observations regarding the unit response during the test.

4.3.3.3 Part 3 Impacts of Spike Concentration Loadings

Part 3 is a test series designed to evaluate the impact that spike loadings may have on the unit's ability to remove key constituents. The key constituents for the Hydro-Kleen™ unit are TSS, TPH, and the organic indicator tests COD and TOC. The test protocol for Part 2 will be used to increase the hydraulic loading to the unit, and increasing the chemical feed pump rates and dry feeder rate will increase the concentration of constituents in the feed water.

Using the same unit (no cleanout or fresh absorbent) as for Part 2, the test procedure will start at a flow rate of approximately 30 gpm. The chemical feed pump rates of the stock solutions and dry feeder will be set at a factor of four (4) times higher than used in the previous tests. This will increase the concentration of constituents by a factor of four. After 15 minutes, the flow will be increased to 40 gpm for a period of 15 minutes. Flow will continue to be increased by an additional 10 gpm (50, 60, 70, etc.) in 15-minute increments until flow begins through the bypass holes. The maximum flow rate achieved before bypass and after bypass begins will be recorded in the logbook. After achieving the maximum treated rate, the flow will continue to be increased to challenge the bypass system. Flow will continue to be increased until either, the bypass is at capacity and the unit begins to flood, or until the maximum available fresh water rate of approximately 100 gpm is reached. All flow rates and operating observations will be recorded in the logbook along with any physical observations regarding the unit response during the test.

Grab samples of the influent and effluent will be collected at each flow rate condition (30, 40, 50 60 gpm, etc.) until the unit floods or the maximum available feed water capacity is reached. All samples will be analyzed for TSS and COD. Two sets of influent and effluent samples will be collected for TPH, TOC, BTEX, and O&G analysis. One set will be collected at the 40 gpm rate and a second sample(s) will be collected at the maximum rate achieved before flooding as determined in Part 2 or at the maximum rate achieved.

At the end of the Phase III tests, the unit will be cleaned and the absorbent material will be replaced as described in Section 4.5.

4.3.4 PHASE IV CONTAMINANT CAPACITIES AT HIGH HYDRAULIC THROUGHPUT

The influence on treatment efficiency of high hydraulic loads on the unit will be tested in Phase 4. The Phase 4 test will be a capacity or "exhaustion test" similar to Phase 2, except the unit will be under higher hydraulic loads typical of a very large flow event. The Hydro-Kleen™ unit is somewhat unique in that it will treat all of the water that can pass through the treatment chambers and then bypass the remaining water. Thus, at higher flows (above treatment capacity) it will not backup and flood an area around the inlet, but rather will treat a set flow, about 50 gpm, and the additional flow will be bypassed to the catch basin outlet and enter the collection system. Only if the bypass flow rate capacity and treatment capacity are exceeded will water begin to backup and flood. Under this high flow rate test, the unit will be operated above the rated treatment capacity with the bypass flowing and removing the extra flow. It is expected that the flow rate will be approximately 80 gpm (approximately 50 gpm to treatment; 30 gpm to bypass), which is above the treatment capacity and about 80% of the available flow rate at the laboratory. The test will demonstrate the system's treatment capability when it is operating in bypass mode. Flow to the unit will be on a continuous basis for a 16-hour period. This time may need adjustment depending on the capacity determined during the Phase II test. The test will start with a clean unit with fresh absorbent.

The vendor claims that the capacity of the unit for petroleum hydrocarbons is approximately the equivalent of 5 gallons of diesel fuel. At an average density of 7.3 lbs/gal for diesel fuel, this would represent about 37 pounds of hydrocarbons. The synthetic mix is expected to have approximately 25 mg/L of total petroleum hydrocarbons. Therefore, the unit should be able to treat approximately 175,000 gallons of flow (assuming 100% removal). At a maximum treated water flow rate of 50 gpm, it will take approximately 58 hours to reach the capacity of the unit. Since the hydrocarbon capacity is relatively high, it is expected that the unit will blind off due to suspended solids loadings prior to hydrocarbon breakthrough. It is anticipated that 16 to 32 hours of running time (48 – 96,000 gallons treated) will be sufficient to reach the solids capacity of the unit. Prior to starting the Phase IV test, the capacity of the unit will have been determined during Phase II and the anticipated run time will be recalculated. If a longer run is needed the unit will be operated for additional time or until capacity is achieved.

Observation of the flow rates through the treatment unit and the bypass will be used as the primary indicator that solids capacity has been reached. When flow rates in the treatment section decrease by 25% or more for 30 minutes, capacity will be considered to have been reached. If for any reason the results after the two 16-hour periods (or alternative time determined in Phase II) indicate exhaustion has not been achieved, then the unit will be started again and will continue to be dosed on the 16-hour schedule until the maximum capacity is reached.

Samples will be collected on a grab sample basis. Samples from the influent and effluent will be collected at the start of the test and after every 10,000 gallons of water treated and analyzed for the primary constituents (TSS, COD). Samples of the effluent will be collected for TPH, BTEX, TOC, O&G, surfactants, total phenols, and metals at the start of the test and after 20,000 gallons treated and at the end of the 16-hour day (48,000 gallons treated). Samples of the influent will be collected for TPH, BTEX, TOC, O&G, surfactants, total phenols, and metals at the start of the test and at the end of the run. Samples of the influent and effluent will be collected from the effluent for nutrients (TKN, Ammonia, T-P) at the beginning and end of the run. If additional 16-hour test period(s) are needed, the same sampling schedule will be maintained. Samples will only be analyzed for water volumes up to the time that unit begins to blind off and the treated water through the filter/absorption media decreases by 25% or more. If the capacity of the unit is found to be larger than 96,000 gallons (two - 16 hour feed days), samples will continue to be collected until the capacity is achieved. Samples collected at the 20,000 and 60,000-gallon volumes will not be analyzed and samples collected later in the test run will be run for the same parameter list.

Flow rates will be monitored throughout the test period on a minimum of a once per hour basis. Cumulative volumes processed during the test will be monitored based on the flow rates. All flows (influent, stock solution feeds, effluent) will be recorded in a permanent logbook, which will also be used to record observations made during the test runs. Observations will include physical description of the effluent water with respect to color, oil sheen, etc. The unit will be observed for any evidence of clogging, change in operating head or head loss, flow patterns, or any evidence of bypass or short-circuiting.

At the end of the Phase IV test, the unit will be cleaned and the absorbent material will be replaced as described in Section 4.5.

4.4 INFLUENT CHARACTERIZATION

4.4.1 SYNTHETIC WASTEWATER

The verification test will be performed using synthetic water made from a mixture of fuels, coolants, washing detergents and soil of various grain sizes. As described in the Generic Protocol for In-Drain Treatment Technologies, this water is intended to simulate actual products that may be present in runoff waters entering a drainage system. No reliable sources of actual waste products could be identified for use in this test, so the materials used will be the products themselves. The following products will be used to make the synthetic wastewater:

- Regular unleaded gasoline
- Truck Diesel Fuel
- 10W-30 motor oil
- Brake fluid
- Antifreeze (glycol based)

- Vehicle washing detergent (specific chemical addition – see below)
- Windshield Washer fluid
- Standards Soils
    - Sand 33% by weight
    - Silt 30% by weight
    - Top soil 21% by weight
    - Clay 16% by weight

These products or materials will be purchased and the same material/product will be used for all tests. The silt component will be represented by taking equal weights of fine sand and clay to simulate the intermediate particle sizes of the silt range. Commercial vehicle detergents often contain considerable levels of linear alkylbenzene sulfonic acid (LAS) and sodium tripolyphosphate (STPP). Since a commercial detergent with a known formulation was not available to the testing laboratory and because STPP is not used in consumer products, the LAS and STPP ingredients are being added in place of a fully formulated vehicle wash detergent to simulate the matrix effects of detergents.

The Generic Protocol gives a targeted concentration for various analytical parameters as shown in Table 4-1.

Table 4-1: **Synthetic Wastewater – Generic Protocol**

Parameter	Concentration (mg/L)
TPH	120
TOC	100
Oil & Grease	100
Benzene	5
Ethylbenzene	<1
Toluene	7
Total Xylenes	6
MTBE	0.007
Total Phenols	10
Total Suspended Solids	300
Metals	9
Surfactants (MBAS)	10
COD	200
PO_4-P	1
TKN	5
NH_3-N	1

During the planning stage for this Test Plan, questions were raised regarding this mix, particularly with respect to the TPH, O&G, TOC, COD, and volatile components. It was not possible to make a mix with these concentrations and the TPH and volatiles concentrations appeared very high. After review with the VO and protocol developers, it was determined that the TPH and O&G needed to be lower and that the units for the volatiles should have been : g/L rather than mg/L. After much discussion, a revised initial target was proposed and several rounds of laboratory testing were performed to try to make an acceptable mix of petroleum products. In preparing the mix, it was agreed that TPH was the critical parameter and that the O&G, TOC and COD would fall at whatever levels matched the targeted TPH. As an example, the original protocol target has a COD to TOC ratio of 2:1 (200 mg/L to 100mg/L), which is not representative of real-world data. Therefore, the VO agreed that the levels of TOC and COD will be based on the mix of oils and fuels being used. Also, O&G by definition of the test will always be equal to or greater than the TPH as both methods are solvent extractions. In this particular mix, the O&G will be similar to the TPH since only petroleum hydrocarbons are being added to the wastewater (no animal or vegetable fats, or greases are being added). Table 4-2 shows the revised initial target concentrations for the synthetic wastewater. The Phase I testing is being conducted in part to provide a shakedown of the protocol to make sure the tests outlined in the protocol can be performed.

Table 4-2: Revised Synthetic Wastewater – Generic Protocol

Parameter	Concentration (mg/L)
TPH	25
TOC	50
Oil & Grease	40
Benzene	0.005
Ethylbenzene	<0.001
Toluene	0.007
Total Xylenes	0.006
MTBE	0.007
Total Phenols	10
Total Suspended Solids	300
Metals	9
Surfactants (MBAS)	10
COD	200
PO_4-P	1
TKN	5
NH_3-N	1

A formula using a mix of the above named products/materials has been made and tested in the laboratory to determine the conformance to these specifications. The synthetic mix that was prepared and tested is shown in Table 4-3.

Table 4-3: Product Mix For Synthetic Wastewater

Product or Material	Concentration in water (mg/L)
Regular unleaded gasoline	0.3
Truck Diesel Fuel	13.6
10W-30 motor oil	68
Brake fluid	3.4
Antifreeze (glycol based)	10
LAS	10
STPP	2
Windshield Washer fluid	10
Standards Soils	300

The mix shown in Table 4-3 was made in the lab and analyzed for the various constituents identified in the generic protocol. The results of the analysis are shown in Table 4-4.

Table 4-4: Analytical Results for Synthetic Wastewater Mix

Parameter	Concentration (mg/L)
TPH	42
TOC	13
Oil & Grease	52
Benzene	0.002
Ethylbenzene	<0.001
Toluene	0.003
Total Xylenes	0.002
MTBE	<0.001
Total Phenols	0.003
Total Suspended Solids	250-300
Metals (Al, Cd, Cr, Cu, Fe, Pb, Zn	2
Surfactants (MBAS)	12
COD	280
PO_4-P	1
TKN	3
NH_3-N	0.2

Total suspended solids is the only parameter that falls within the range of the guidance concentrations based on the GP requirement that concentrations fall within plus or minus 50% of the guidance levels. The synthetic mix (after repeated attempts) has been determined to have approximately the correct range of hydrocarbons as measured by TPH. It does not appear feasible to make and feed a wastewater that can maintain at all times TPH within a $\pm$50% window at these concentration levels, given the use of "real" world products, the precision of the analytical method, and the variability of sampling for these types of materials. The targeted level of 25 mg/L is within a factor of 2.5 of the detection limit for TPH (10 mg/L), which results in greater variability in the results at the lower levels. Each time an adjustment in the mix is made the entire data set changes significantly in relationship to the acceptance criteria of plus or minus 50%. Therefore, this Test Plan proposes to use the established mix and set a window of 20-60 mg/L as an acceptable window for TPH in the influent stream. The other organic indicators, COD, TOC, BETX and O&G, vary from the recommended mix. This appears to be caused by the analytical response of the indicator tests to the hydrocarbons being measured and variation in the products in the case of BETX. The key parameters for the verification for the Hydro-Kleen™ unit are TPH and TSS. Therefore, the mixture is focused on the requirements for these parameters. The other organic parameters are present in the mix, but may be outside the range of the generic mix as defined by the plus or minus 50% criteria. These parameters will be monitored and the results reported as they occur in the product mix, without absolute acceptance criteria. In the case of metals and nutrients, no additional materials were used to spike these constituents, as they are secondary parameters. The amount present in the synthetic mix is the amount contributed by the products selected for use. It does not appear possible to get "dirty" organically bound metals for use in the test. Spiking with inorganic metals would not add anything to the test, as the unit is not designed for removal of inorganic metals constituents. The same is true for nutrients. The vendor makes no claims for nutrients and does not expect to reduce the nutrient levels.

4.4.2 STOCK SOLUTIONS

The standard mix determined above (Table 4-2) will be used for all of the verification tests. A stock solution of the fuel materials (gasoline, diesel fuel, motor oil, and brake fluid) will be made containing the proper ratio of these materials. This stock will be the petroleum fuels stock for injection into the fresh water stream. The antifreeze, washer fluids, and detergent will be added to a tank containing water that will be the water-soluble stock feed solution. The petroleum products stock will be a pure mixture of the fuels blended at the correct ratio to obtain the desired influent concentration. Both of these stock materials will be made up in 55-gallon tanks (drums) and used throughout the test. The clay, topsoil, and sand will be fed from the dry feeder and set to meet the concentration targets in the established mix. The solids will be premixed prior to filling the dry feeder hopper to homogenize the solids feed. The hopper will be refilled frequently to ensure that the solids do not separate during the test.

4.4.3 INFLUENT CHARACTERIZATION DURING THE VERIFICATION TESTING

The influent synthetic wastewater will be sampled and analyzed during all of the various test conditions described in Phases I–IV in Section 4.3. While the generic protocol allowed for single daily samples of the influent in several test cases, the approach used in the Test Plan is to match influent and effluent samples as often as possible for all sampling periods. This will ensure that the actual influent concentrations will be known for all test conditions.

Because of the large water volumes needed for these tests it was not practical to make a single large daily batch of synthetic water to supply the entire day's flow. Instead, the system will use more concentrated stock solutions that will be injected into the fresh water flow in the open channel. Given the potential for some variation in the actual mixed influent water, the Test Plan calls for influent samples, both grab and flow-weighted composites from the manual grabs, to be matched with the effluent samples. This will serve as a check on the feed systems and insure representative influent data is available for determining unit treatment and removal efficiencies. Table 5-1 in the Sampling and Analysis Plan shows a summary of all samples being collected during each phase of testing.

4.5 EFFLUENT CHARACTERIZATION

The effluent quality will be monitored during all Phases of testing except during the fresh water hydraulic test in Phase III, Part 1. Treated effluent grab samples ands flow-weighted composite samples from manual grab samples will be collected. The sampling plan shows the details of the actual samples being collected in Table 5-1. The sampling and analysis approach focuses frequent sample collection and analysis on the key parameters for evaluating the Hydro-Kleen™ unit as described previously. Less frequent sampling and analysis is scheduled for secondary parameters.

The primary parameters will be used to evaluate the efficiency of treatment by providing a sound basis for comparing influent water quality with effluent water quality. The secondary parameters will also provide information on the unit's capability to remove these constituents and will also provide general information on the fate of certain contaminants that are typically found in stormwater as they pass through the unit. This is particularly true for nutrients, which the unit will only remove if they are in the insoluble form and settle with the solids or if they are bound to organic materials that are absorbed as part of the petroleum hydrocarbon absorption process.

Specific details on the sampling and analysis frequency and parameter list is provided in the Sampling and Analysis Plan Section and in the previous sections describing the test phases.

4.6 RESIDUE MANAGEMENT

Residues, including sediment in the settling chamber and the absorbent media, will be removed from the unit at the end of some Phases of testing as described in Section 4.3. Measurements will include the volume of residues/media collected and the wet weight of residues/media collected. These data will be used to provide information on typical cleanout volume and weights that can be expected from normal operation.

Solid residues will be collected from the sedimentation chamber in the unit. The sediment will be removed using a vacuum system (dry/wet shop vacuum) to simulate the typical removal system used in the field (vacuum truck). The content of the shop vacuum reservoir will be removed using scoops, spatulas, scrapers, etc. to remove as much material as possible. These solids will be measured for wet weight and volume in order to evaluate the amount of solids that can be expected to be generated and cleaned out of the unit on a volume throughput/loading basis. Samples of the solids will also be measured for solids content so that a dry weight of solids produced can also be calculated. Three sub samples of the sediment will be collected and percent solids measured. The weight of solids collected will be used to relate the accumulation rate of solids to total water treated.

One sample from each collection period (expect two or three) will be analyzed using the Toxicity Characteristic Leachate Procedure (TCLP) prior to disposal, if there is sufficient sample to run the analysis. The leachate will be analyzed for metals and for applicable organic materials.

The spent absorbent material will also be generated as a residue. The absorbent will be drained and then weighed to determine the weight and volume of material that will require disposal. A sample of each absorbent material will also be tested using TCLP and the leachate will be analyzed for metals and applicable organics.

4.7 OPERATION AND MAINTENANCE OBSERVATIONS

The Hydro-Kleen™ unit will be installed and operated by NSF during the test period. The vendor-supplied Operations and Maintenance Manual is presented in Appendix A. Hydro Compliance will also provide consultation on installation and operation of the unit.

Installation of the unit is expected to be straight forward as the unit is designed to match the opening size of the catch basin or drain inlet provided by the purchasers. The unit is placed under the grating and is supported by the collar that is sized to fit the opening. NSF will have access to all parts of the unit during testing. The unit's simple design provides ready access to all parts of the unit and all parts of the unit can be easily observed during operation.

There are no electrical or mechanical control systems for the unit, no utility hook-ups, and no moving parts. The unit does not have any alarms or indicators to alert users to maintain the unit.

Hydraulics Laboratory personnel will maintain a detailed logbook describing all observations made during the tests. Any unit cleaning, clearing of debris, unclogging of the unit, etc. will be recorded. Observations will also be recorded on the ease/difficulty of installation, operation, and maintenance. These observations will include a qualitative assessment of the degree of difficulty encountered during the cleaning of the unit at the end of each phase and on the ease/difficulty of replacing the absorption media.

Flow rates, volume of water processed, amount of stock solutions pumped from the stock feed tanks, and related operational data for each test run shall be recorded in the operational log. Any deviations or changes from the prescribed Test Plan shall be thoroughly documented. The measurements of residue volumes and weights will be recorded after cleaning periods.

Any other observations on the operating condition of the unit or the test system as a whole shall be recorded for future reference. Observations of changes in effluent quality based visual observations, such as color change, oil sheen, obvious sediment load, etc., will be recorded for use during the Verification Report preparation.

The operating and maintenance logbook(s) will be important records for use during the Verification Report preparation. These logs will provide the information to validate the flow and operating conditions during the test periods. Further, they will serve as the basis for making qualitative performance determinations regarding the unit's operability and the level/degree of maintenance required.

5.0 SAMPLING AND ANALYSIS PLAN

5.1 SAMPLING LOCATIONS

There are two primary sampling locations in the laboratory test system. As shown in Figure 3-5, the two locations are the influent sampling location just upstream of the entrance to the unit and the treated effluent sampling location located just downstream of the test unit discharge. Each of these sampling locations is setup so that grab samples can be collected directly into sample containers. Flow-weighted composites for this Test Plan are straight forward as all test conditions call for a steady flow rate for a set period of time. Therefore, a set sample volume can be collected on a cumulative flow basis and a flow-weighted composite will be obtained.

In addition to the influent and effluent wastewater samples being collected throughout the four phases of testing, samples will also be collected of the solids and absorbent material at the end of each test phase. These samples will be manual grab samples collected from the residue material obtained from the test unit. The solids will be removed from the sedimentation chamber by vacuuming the chamber and then collecting the residue from the vacuum reservoir. The residue will be placed in a container for weight and volume measurement. Three sub samples will be obtained from the container for chemical and physical analyses. The two absorption/filter media bags will be cut open and sub-sampled for analysis. The contents of each media bag will be sampled and analyzed separately.

5.2 SAMPLING FREQUENCY

Sampling type, frequency and the analytical list will vary for each phase of the testing. The sampling is discussed in narrative form in the experimental design section. A summary table showing all of the sampling by Phase is presented in Table 5-1.

Table 5-1: Sampling Locations, Frequency, Type, and Analysis

Phase	Sample Location	Frequency	Type	Analysis
Phase I				
Day 1,3	Influent and Effluent	1 daily sample each day	Composite flow-weighted over 8 hours	TOC, TPH, T-Phenol, MBAS, T-P, TKN, NH3, Metals
	Influent and Effluent	8 1 hour samples	Composite flow-weighted over 1 hour	TSS, COD
	Influent and Effluent	1 time each day	Grab	BETX, MTBE
	Influent and Effluent	1 daily sample each day	Grab	O&G
Day 2,4,5	Influent and Effluent	1daily sample each day	Composite flow-weighted	TSS, TOC, COD, T-Phenol, MBAS, T-P, TKN, NH3, Metals
	Influent and Effluent	1 time each day	Grab	TPH, BETX, MTBE
	Influent and Effluent	1 daily sample each day	Grab	O&G

Table 5-1: Sampling Locations, Frequency, Type, and Analysis (cont'd)

Phase II				
Capacity Study	Influent and Effluent	1 sample at startup 1 sample/10,000 gal treated 1 sample at end of run – 40,000 gallons	Grab	TSS, COD
	Effluent	1 sample at startup 1sample at 20,000 gals treated 1sample at end of run – 40,000 gallons	Grab	TPH, BTEX, MTBE, TOC, O&G, MBAS, T-Phenol, Metals
	Influent	1 sample at startup 1sample at end of run – 40,000 gallons	Grab	TPH, BTEX, MTBE, TOC, O&G, MBAS, T-Phenol, Metals
	Influent and Effluent	1 sample at startup 1 sample at end of run	Grab	T-P, TKN, NH3
Phase III				
Part 1	No samples			
Part 2	Influent and Effluent	1 sample per flow rate (30, 40, 50, 60 gpm, etc)	Grab	TSS, COD
	Influent and Effluent	2 samples – One at 40 gpm and one at max flow rate achieved	Grab	TPH, TOC, BTEX, MTBE, O&G,
Part 3	Influent and Effluent	1 sample per flow rate (30, 40, 50, 60 gpm, etc)	Grab	TSS, COD
	Influent and Effluent	2 samples – One at 40 gpm and one at max flow rate achieved	Grab	TPH, TOC, BTEX, MTBE, O&G,
Phase IV				
	Influent and Effluent	1 sample at startup 1 sample/10,000 gal treated 1 sample at end of run- 40,000 gallons	Grab	TSS, COD
	Effluent	1 sample at startup 1 sample at 20,000 gals treated 1 sample at end of run	Grab	TPH, BTEX, MTBE, TOC O&G, MBAS, T-Phenol, Metals
	Influent	1 sample at startup 1 sample at end of run	Grab	TPH, BTEX, MTBE, TOC O&G, MBAS, T-Phenol, Metals
	Influent and Effluent	1 sample at startup 1 sample at end of run	Grab	T-P, TKN, NH3

5.3 SAMPLE COLLECTION, PRESERVATION, AND STORAGE

There are two basic types of samples being collected for this verification test, grab samples and flow-weighted composite samples from the grab samples. The flow-weighted composite samples will be collected by taking manual grab samples of a set volume at predetermined cumulative flow points (i.e., 10,000, 20,000, 30,000 gallons, etc.) Flow-weighted composites are only being collected during Phase I, when the flow rate to the unit is held constant for all testing. Samples will be collected only when the unit is actively being dosed with water.

The samples for TPH and TSS will require special handling and compositing in the laboratory. The samples for TPH will be collected in individual 250 mL glass containers that will be cooled after sample collection. The individual bottles will be sent to the laboratory where they will be combined into one sample. Each bottle will be rinsed with hexane and the hexane will be added to the entire sample for the extraction process. This approach allows for making a composite sample and ensuring all the TPH will be measured.

The grab samples for TSS will be collected in individual 40 mL glass vials. All of the sample from each bottle will be used to run the analysis. This is necessary to insure that the heavier sand particles are included in the sample. Pre-testing in the laboratory has shown that it is difficult to collect an aliquot from a sample bottle containing sand and obtain a representative sample that includes the heavier sand. Further, the clay present in the sample tends to blind the filter paper. Therefore, the sample size must be kept small in order to pass the entire sample through the filter in a reasonable timeframe. The procedure for suspended solids analysis will be to use the entire contents of each TSS sample bottle. The volume of the sample will be recorded and the entire contents will be filtered for TSS measurement. The bottle will be rinsed to remove any remaining solids and the rinseate added to the sample being filtered. The flow-weighted composite result (either one hour or eight hour composites) will be determined one of two ways. If the sample from an individual bottle filters easily, then more than one sample bottle (individual grab) may be filtered through the same filter paper. In the case of the one-hour composites, two grab samples (two collected per hour) may be filtered together, yielding a single flow-weighted composite result. The same approach may be used for the eight-hour composite, which will consist of four sample bottles (one every two hours) instead of two bottles. In this approach, the TSS concentration will be determined by dividing the total mass of dry solids measured on the filter(s) by the original sample volume (without rinseate volume) of the two or four bottles. The alternative, if only one vial of sample (individual grab) can be passed through a filter, will be to filter each grab sample individually. The dry weight of solids from the individual samples will be added together and the total dry solids weight divided by the total sample volume (of two or four vials) to calculate the TSS concentration. The samples for TOC, COD, nutrients, and metals will be collected in one- or two-liter glass containers. Preservatives will be added to the container after the sample is collected. The containers will be cooled during sample collection. At the end of the day, the samples will be well mixed and poured into individual sample containers. Grab samples for volatiles (BETX and MTBE) and O&G will be collected directly into the sample containers to avoid any loss of volatiles during sample handling. Table 5-2 shows the bottle types, sample size, and preservation required for each parameter.

The NSF Chemical Laboratory will provide the sample bottles required for the various analyses. The bottles will come without preservative. The preservative will be added to the bottle after the sample is collected. The samples will be pre-labeled by analysis type.

The NSF Hydraulics Laboratory is in the same building as the Chemical Laboratory. The Chemical Laboratory will perform most of the analysis and will arrange for a subcontract laboratory for a few analyses. Given the proximity of the laboratories, samples will be hand-delivered to the laboratory login desk with appropriate NSF project approval forms and chain of custody forms. The samples will be logged and placed in refrigeration as needed. Because of the proximity of the labs, coolers with ice to maintain temperature will not be needed for interim storage or transport. For analyses that will be sent to TriMatrix, the samples will be prepared for shipment by the NSF Chemical Laboratory, using a new chain of custody. Samples will be placed in coolers with ice to maintain temperature, and will be picked up and transported by TriMatrix.

Table 5-2: Preservation, Bottle Type, And Sample Size By Analysis

Sample Matrix	Analyses	Bottle type, size	Preservation, Holding Time
LIQUID	pH	Plastic 250 mL	None, analyze immediately
	TPH	Glass, 1L or 250 mL	Cool to 4 degrees C, pH < 2 H2SO4, 28 day
	TOC	Glass, 2- 40 mL vials	Cool to 4 degrees C, pH < 2 H2SO4, 28 days
	Oil & Grease	Glass, 1L	Cool to 4 degrees C, pH < 2 H2SO4, 28 days
	BETX and MTBE	Glass, 6 - volatiles vials 40 mL	Cool to 4 degrees C, pH < 2 HCl, 20-40mg ascorbic acid, 14 days
	Total Phenols	Amber Glass, 250 mL	Cool to 4 degrees C, pH < 2 H2SO4, 24 hrs
	Total Suspended Solids	Glass, 40 mL vials	Cool to 4 degrees C, 7 days
	Metals	Plastic 125 mL	pH < 2 HNO3, six months
	Aluminum		
	Cadmium		
	Chromium		
	Copper		
	Iron		
	Lead		
	Zinc		
	Surfactants (MBAS)	Amber glass, 250 mL	Cool to 4 degrees C, 48 hrs
	COD	Amber glass, 250 mL Plastic 100 mL	Cool to 4 degrees C pH < 2 H2SO4, 28 days
	PO_4-P	Amber glass, 250 mL	Cool to 4 degrees C, pH < 2 H2SO4, 28 days
	TKN and NH_3-N	Amber glass, 250 mL	Cool to 4 degrees C, pH < 2 H2SO4, 28 days
SOLID			
	TCLP	Glass 250 mL or larger, Special handling if for volatiles	Cool to 4 degrees C
	Total Solids	Plastic or glass, 500 mL	Cool to 4 degrees C

5.4 CHAIN OF CUSTODY

Chain of Custody will be maintained for all samples collected during the verification test. The unit operators who are responsible for sample collection will fill out an NSF project approval form (See example in Appendix C) for each set of samples. The form will be signed and dated for each set of samples delivered to the NSF laboratory. The receiving technician will acknowledge receipt of the samples by signing the project approval form and providing a copy of the form to the sample delivery person. All project approval and chain of custody records will be maintained by the Hydraulics Laboratory and by the Chemical Laboratory for all samples. Copies of the completed project approval forms will be included with all laboratory reports transmitting final analytical results.

Samples that will be sent to TriMatrix will have a new chain of custody prepared for shipment of the samples (See example in Appendix C). The same procedure will be followed as for the NSF Chemical Laboratory. The person preparing the samples for shipment will prepare and sign the chain of custody form and send it with the samples. The receiving lab will sign the form acknowledging receipt of the samples and will return a copy of the final chain of custody form with the final laboratory reports.

5.5 ANALYTICAL METHODS

All of the analytical methods used during the verification test will be USEPA-approved methods or methods from Standards Methods for the Examination of Water and Wastewater, 20th Edition. Table 5-3 shows the analytical methods that will be used for the verification test and the typical detection limits achieved by these methods.

Table 5-3: Analytical Methods

Sample Matrix	Analyses	Reference Methods	Reporting Detection Limit for matrix (i.e., PQL or normal reporting limit)
LIQUID	pH	150.1	N/A (range 1-13 S.U.)
	TPH*	EPA 1664A SGT-HEM	5 mg/L
	TOC	SM 5310C	0.3 mg/L
	Oil & Grease*	EPA 1664 HEM	2 mg/L
	BETX*	SW 846 8021B	0.5 µg/L per component
	MTBE*	SW 846 8021B	0.5 µg/L
	Total Phenols	EPA 420.4	0.001 mg/L
	Total Suspended Solids	EPA 160.2	2 mg/L
	Metals	EPA 200.8	
	Aluminum		10 mg/L
	Cadmium		0.3 mg/L
	Chromium		0.001 mg/L
	Copper		0.002 mg/L
	Iron		0.02 mg/L
	Lead		0.001 µg/L
	Zinc		0.002 mg/L
	Surfactants (MBAS)	SM 5540C	0.2 mg/L
	COD*	EPA 410.4	3 mg/L
	PO_4-P*	EPA 365.1	0.01 mg/L
	TKN*	EPA 351.2	0.5 mg/L
	NH_3-N*	EPA 350.1	0.05 mg/L
SOLID			
	TCLP*	SW 846 - 1311	N/A
	Total Suspended Solids	EPA 160.2	5 mg/kg

* = Analysis to be conducted at TriMatrix

The laboratories will report all results with all associated QC data. The results will include all volume and weight measurements for the samples, field blank results, method blanks, spike and spike duplicate results, results of standard check samples and special QC samples, and appropriate calibration results. All work will be performed within the established QA/QC protocol as described in the Quality Assurance Project Plan (Section 6) and as outlined in the laboratory SOPs and the NSF Chemical Laboratory QA/QC Plan. Any deviations from the standard test procedures or difficulties encountered during the analyses will be documented and reported with the data.

6.0 QUALITY ASSURANCE/QUALITY CONTROL PROJECT PLAN

The purpose of this section is to describe the quality assurance/quality control program that will be used during the VTP to ensure that data and procedures are of measurable quality and supports the quality objectives and Test Plan objectives for this verification test. The quality assurance activities and scope are based on the guidance provided in the Protocol for the Verification of In-Drain Treatment Technologies. The plan has been developed with guidance from the USEPA's Guidance for Quality Assurance Project Plans and Guidance for the Data Quality Objectives Process. The QA/QC plan is tailored to this specific Test Plan and requirements for verification of the Hydro Compliance Hydro-Kleen™ Filtration System in this application. The QA/QC Plan is written as part of the Verification Test Plan and should be read and used with the VTP as a reference. The VTP contains descriptions of various requirements of the QA/QC Plan, and they are incorporated by reference at several locations.

6.1 VERIFICATION TEST DATA – DATA QUALITY INDICATORS (DQIs)

Several Data Quality Indicators (DQIs) have been identified as key factors in assessing the quality of the data and in supporting the verification process. These indicators are:

- Precision
- Accuracy
- Representativeness
- Comparability
- Completeness

Each DQI is described below and the goals for each DQI are specified. Performance measurements will be verified using statistical analysis of the data for the quantitative DQIs of precision and accuracy. If any QA objective is not met during the tests, an investigation of the causes will be initiated. Corrective Action will be taken as needed to resolve the difficulties. Data failing to meet any of the QA objectives will be flagged in the Verification Report and a full discussion of the issues impacting the QA objectives will be presented.

6.1.1 PRECISION

Precision refers to the degree of mutual agreement among individual measurement and provides an estimate of random error. Analytical precision is a measurement of how far an individual measurement may deviate from a mean of replicate measurements. Precision is evaluated from analysis of field and laboratory duplicates and spiked duplicates. The standard deviation (SD), relative standard deviation (RSD) and/or relative percent difference (RPD) recorded from sample analyses are methods used to quantify precision. Relative percent difference is calculated by the following formula:

$$RPD = [(C_1 - C_2) / (C_1 + C_2) / 2] \ \text{x} \ 100\%$$

Where:

C_1 = Concentration of the compound or element in the sample

C_2 = Concentration of the compound or element in the duplicate

Field duplicates will be collected of both influent and effluent samples. The field duplicates will be collected at a frequency of one duplicate for every ten samples collected of influent and effluent. The laboratory will run duplicate samples as part of the laboratory QA program.

Duplicates are analyzed on a frequency of one duplicate for every ten samples analyzed. The data quality objective for precision is based on the type of analysis performed. Table 6-2 shows the laboratory precision that has been established for each analytical method. The data quality objective varies from a relative percent difference of ± 10% to ± 30%.

6.1.2 ACCURACY

Accuracy is defined for water quality analyses as the difference between the measured value or calculated sample value and the true value of the sample. Spiking a sample matrix with a known amount of a constituent and measuring the recovery obtained in the analysis is a method of determining accuracy. Using laboratory performance samples with a known concentration in a specific matrix can also monitor the accuracy of an analytical method for measuring a constituent in a given matrix. Accuracy is usually expressed as the percent recovery of a compound from a sample. The following equation will be used to calculate Percent Recovery:

$$\text{Percent Recovery} = [(A_T - A_i) / A_s] \times 100\%$$

Where:

A_T = Total amount measured in the spiked sample

A_i = Amount measured in the un-spiked sample

A_s = Spiked amount added to the sample

During the VTP analyses the laboratory will run matrix spike samples at a frequency of one spiked sample for every 15 samples analyzed for solid and liquid samples. The laboratory will also analyze liquid and solid samples of known concentration as lab control samples. The accuracy objectives by parameter or method are shown in Table 6-2.

6.1.3 COMPARABILITY

Comparability will be achieved by using consistent and standardized sampling and analytical methods. All analyses will be performed using USEPA or other published methods as listed in the analytical section (Table 5-3). Any deviations from these methods will be fully described and reported as part of the QA report for the data. Comparability will also be achieved by using National Institute of Standards (NIST) traceable standards including the use of traceable measuring devices for volume and weight. All standards used in the analytical testing will be traceable to verified standards through the purchase of verifiable standards and maintaining a standards logbook for all dilutions and preparation of working standards.

Comparability will be monitored through QA/QC audits and review of the test procedures used and the traceability of all reference materials used in the laboratory.

6.1.4 REPRESENTATIVENESS

Representativeness is the degree to which data accurately and precisely represent a characteristic population, parameter at a sampling point, a process condition, or an environmental condition. The Test Plan design calls for grab samples of influent and effluent to be collected and then analyzed individually or as flow-weighted composites. The sampling locations for the grab samples are designed for easy access and for collection of a large cross-section of the flow in the bottle. This design will help ensure that a representative sample of the flow is obtained in each sample bottle. Composite samples will be made from the grab samples. The compositing procedure includes a thorough mixing of the individual samples prior to pouring the samples in to the composite container. The laboratory will follow set procedures (in accordance with good laboratory practice) for thorough mixing of any samples prior to sub-sampling in order to ensure that samples are homogenous and representative of the whole sample. In addition, special sample handling procedures for TPH and TSS have been incorporated in the Test Plan to ensure composite samples for these constituents are prepared properly. These procedures include using the entire grab sample(s) for the analysis, thus having the composite made in the laboratory rather than at the time of sample collection. These special procedures are described in Section 5.3.

The laboratory setup for this test has been designed and reviewed to determine that it is representative of a typical catch basin inlet (gravity flow through a grate) and is typical of the standard application/installation for this treatment technology. The Hydro-Kleen™ unit will be operated in a manner consistent with the vendor-supplied O&M manual so that the operating conditions will be representative of normal installation and operation for this equipment.

Representativeness will be monitored through QA/QC audits (both field and laboratory), including review of the laboratory procedures for sampling handling and storage, review and observation of the sample collection, and review of the operating logs maintained at the test site.

6.1.5 COMPLETENESS

Completeness is a measure of the number of valid samples and measurements that are obtained during a test period. Completeness will be measured by tracking the number of valid data results against the specified requirements in the Test Plan.

Completeness will be calculated by the following equation:

$$\text{Percent Completeness} = (V / T) \times 100\%$$

Where:

V = number of measurements that are valid

T = total number of measurements planned in the test

The goal for this data quality objective will be to achieve minimum 80% completeness for samples scheduled in the Test Plan.

6.2 PROJECT MANAGEMENT

6.2.1 MANAGEMENT TEAM

The TO is responsible for management of the VTP including meeting the VTP objectives and the Data Quality Objectives. Section 2 of the VTP describes the key personnel involved in this ETV program and the persons responsible to implement the Test Plan, including a Quality Control Officer from NSF who will be responsible for audits, assessment, and review of procedures and quality data. The phone number, email address, and mailing address for each person named are given in Section 2.

6.2.2 PROJECT DESCRIPTION AND OBJECTIVES

A full description of the project history, the Hydro-Kleen™ technology being verified, and the objectives has been presented in Sections 1 through 3 of the VTP. A brief summary of the project is presented herein. Sections 4 and 5 describe the experimental design and the Sampling and Analysis Plan for the verification test. The reader is referred to the VTP for more details.

The Hydro-Kleen™ Filtration System is a patented multi-media filtration design that includes sediment containment and overflow protection. The unit is designed for use in catch basins and drain inverts as an in-drain treatment technology. Each unit is manufactured to fit the specific catch basin or drain invert. Units are placed into existing catch basins by removing the grate/cover, inserting the unit into the basin and replacing the cover. Water flow enters the unit and is directed into a sedimentation chamber, which collects coarse sediment/solids and debris passing through the inlet grate. Water then passes from a transition inlet at the top of the sedimentation chamber into the filtration chamber. The first media, Sorb-44, catches hydrocarbon contamination through absorption onto a hydrophobic pulp material. The second media is an activated carbon (AC-10), which polishes any remaining hydrocarbons in the water and may remove a variety of organically bound metals and other contaminants in the runoff. Water then passes through the bottom into the catch basin.

Units are designed to trap contaminants contained in water flowing through the unit during flow events, while providing overflow protection to ensure sufficient flow can pass through the catch basin or drain inlet during large flow events. The unit is designed to by-pass larger flows, which eliminates flooding caused by plugging in the unit during heavy wet weather events. Figure 3-1 shows the Hydro-Kleen™ Filtration System. The treatment unit that will be tested in this verification is a full scale, commercially-available unit.

The primary objective of the ETV is to measure the performance of this technology through a well-defined Test Plan that includes measurement of key parameters in the wastewater before and after application of the treatment technology. This objective will be accomplished by implementing the sampling and analysis program described in Section 5 and by meeting the data quality objectives described in this Quality Assurance Project Plan. The Test Plan includes characterizing the synthetic wastewater, installing and operating the Hydro-Kleen™ unit, and measuring the influent to and effluent from the unit, and all residuals removed and contained within the Hydro-Kleen™ unit. The primary parameters being measured are TPH, TSS, COD, TOC and volatile organics (BETX and MTBE). Other parameters will include nutrients, metals, surfactants, Oil and Grease, Total Phenols, and pH. The volume and weight of the residuals will be measured.

6.2.3 PROJECT SCHEDULE

The test elements for this project are divided into four (4) Phases. Phase I is a five-day test run under normal operating conditions. Phases II and IV are capacity tests that are expected to be completed in one to three days for each phase of testing. Phase III is a hydraulic capacity test and spike loading test that is expected to require one to two days of system operation. Table 5-1 shows the sampling schedule by Phase.

6.3 MEASUREMENTS AND DATA ACQUISITION

6.3.1 SAMPLE COLLECTION AND CHAIN OF CUSTODY

There are two basic types of samples being collected for this verification test, grab samples and flow-weighted composite samples. The flow-weighted composite samples will be collected by taking manual grab samples of a set volume at predetermined cumulative flow points (i.e., 10,000, 20,000, 30,000 gallons, etc.) Flow-weighted composites are only being collected during Phase I, when the flow rate to the unit is held constant for all testing. Samples will be collected only when the unit is actively being dosed with water.

Two special sampling and analysis procedures will impact the normal field and laboratory approach to sample handling and analysis. The grab samples for TPH will be collected in individual 250 mL glass containers that will be cooled after sample collection. The individual bottles will be sent to the laboratory where they will be combined into one sample. Each bottle will be rinsed with hexane and the hexane will be added to the entire sample for the extraction process. This approach allows for making a composite sample and ensuring all the TPH will be measured. The grab samples for TSS will be collected in individual 40 mL glass vials. All of the sample from all of the bottles will be used to run the analysis. This is necessary to insure that the heavier sand particles are included in the sample analysis. Pre-testing in the laboratory has shown that it is difficult to sub sample from a sample bottle containing sand and obtain a representative sample that includes the heavier sand. Further, the clay present in the sample tends to blind the filter paper. Therefore, the sample size must be kept small in order to pass all of the water through the filter in a reasonable timeframe. The procedure for suspended solids analysis will be to use the entire contents of each TSS sample bottle. The volume of the sample will be recorded and the entire contents will be filtered for TSS measurement. The bottle will be rinsed to remove any remaining solids and the rinseate added to the sample being filtered. The flow-weighted composite result (either one-hour or eight-hour composites) will be determined one of two ways. If the sample from an individual bottle filters easily, then more than one sample bottle (individual grab) may be filtered through the same filter paper. In the case of the one-hour composites, two grab samples (two collected per hour) may be filtered together, yielding a single flow-weighted composite result. The same approach may be used for the eight-hour composite, which will consist of four sample bottles (one every two hours) instead of two bottles. In this approach, the total mass of dry solids measured on the filter(s) will be divided by the original sample volume (without rinseate volume) of the two or four bottles to determine the TSS concentration. The alternative, if only one vial of sample (individual grab) can be passed through a filter, will be to filter each grab sample individually. The dry weight of solids from the individual samples will be added together and the total dry solids weight divided by the total sample volume (of two or four vials) to calculate the TSS concentration.

The samples for TOC, COD, nutrients and metals will be collected in one or two liter glass containers with the appropriate preservative(s) in the container. The containers will be cooled during sample collection. At the end of the day, the samples will be well mixed and poured into individual sample containers. Grab samples for volatiles (BETX and MTBE) will be collected directly into the sample containers to avoid any loss of volatiles during sample handling. Grab samples for O&G will also be collected directly into the sample bottle. Table 5-2 shows the bottle types, sample size, and preservation required for each parameter.

The NSF Chemical Laboratory will provide the sample bottles required for the various analyses. The bottle will be labeled by analysis type.

The NSF Hydraulics Laboratory is in the same building as the Chemical Laboratory. The Chemical Laboratory will perform most of the analysis and will arrange for TriMatrix for the analyses listed on Table 5-3. Given the proximity of the NSF Hydraulics and Chemical Laboratories, samples will be hand delivered to the laboratory log in desk with appropriate chain of custody forms. The samples will be logged in and placed in refrigeration as needed. Because of the proximity of the labs, coolers with ice to maintain temperature will not be needed for interim storage or transport.

For analyses that will be sent outside, the samples will be prepared for shipment by the Chemical Laboratory, using a new chain of custody. Samples will be placed in coolers with ice to maintain temperature and will be shipped to the outside laboratory. More details on the sample collection procedures are given in Section 5.

Chain of Custody will be maintained for all samples collected during the verification test. The unit operators who are responsible for sample collection will fill out a chain of custody form (See example in Appendix C) for each set of samples. The form will be signed and dated for each set of samples delivered to the NSF Chemical Laboratory. The receiving technician will acknowledge receipt of the samples by signing the chain of custody and providing a copy of the form to the sample delivery person. All project approval and chain of custody records will be maintained by the Hydraulics Laboratory and by the Chemical Laboratory for all samples. Copies of the completed project approval and chain of custody forms will be included with all laboratory reports transmitting final analytical results.

Samples that will be sent to an outside laboratory will have a new chain of custody prepared for shipment of the samples to TriMatrix. The same procedure will be followed as for the NSF Chemical Laboratory. The person preparing the samples for shipment will prepare and sign the chain of custody form and send it with the samples. The receiving lab will sign the form acknowledging receipt of the samples and will return a copy of the final chain of custody form with the final laboratory reports.

6.3.2 ANALYTICAL METHODS

All of the analytical methods used during the verification test will be USEPA-approved methods or methods from Standards Methods for the Examination of Water and Wastewater, 20th Edition. Table 5-3 shows the analytical methods that will be used for the verification test and the typical detection limits that are achieved by these methods.

6.3.3 ANALYTICAL QUALITY CONTROL

The quality control procedures for blanks, spikes, duplicates, calibration of equipment, standards, reference check samples and other quality control measurements will follow the guidance in the USEPA methods, the NSF SOP's, and the NSF Laboratory Quality Assurance Manual, and TriMatrix Quality Assurance Manual. Table 6-1 shows the frequency of analysis of various quality control checks. Table 6-2 shows the quality control limits that will be used by the laboratory for these analyses and to ensure compliance with the DQI for accuracy and precision. Field and laboratory duplicates will be performed at a frequency of one duplicate per ten samples collected. Samples will be spiked for accuracy determination at a frequency of one sample per fifteen samples analyzed by the laboratory. Accuracy and precision will be calculated for all data using the equations presented in Section 6.1.

Table 6-1: Summary of Calibration Frequency and Criteria

Analysis (Reference Methods)	Calibration Frequency	Calibration Points	Acceptance Criteria
pH (150.1)	Initial Calibration daily Check calibration after every 5 non-calibration analyses	Initial Calibration: Two buffers 4-7 or 7-10 Independent buffer at 7 (ICV) Continuing Calibration Check: Alternate pH 7 and 10 (CCV) Or pH 4 and 7 (CCV) Depending on initial calibration range	Initial: ICV ± 0.1 s.u. Continuing: CCV ± 0.1 s.u.
Metals	Initial Calibration daily Check calibration after every 10 non-calibration analyses	Initial Calibration: 5 standards and blank (ICB) Low- to mid-range standard from alternative source (ICV standard) blank (ICB blank) Continuing Calibration Check: low- to mid-range standard from alternative source (ICV standard) blank (ICB blank)	Initial: Correl. Coeff. ≥0.995 ICV ±10% of Theo. Value ICB <RDL Continuing: CCV ±10% of Theo. Value CCB <RDL
TPH	Calibrate balance daily NIST traceable weights	Method Blank each set Check std each set	Blank < RDL ± 15 % of theo. value
TOC	Calibrate at start of Each run	Three point standard curve, blank Continuing Calibration Check: mid-range standard from alternative source standard (CCV) blank	Initial: Correl. Coeff. ≥0.995 Blank <RDL Continuing: CCV ±10% of Theo. Value Blank <RDL
Oil & Grease	Calibrate balance daily NIST traceable weights	Method Blank each set	Blank < RDL
BTEX	Initial Calibration weekly Check calibration after every 10 non-calibration analyses	Three point standard curve, blank Continuing Calibration Check: mid range standard daily Blank Mid-range standard from alternative source standard (CCV) weekly	Initial: Correl. Coeff. ≥0.995 Blank <RDL Continuing: CCV ±10% of Theo. Value

Table 6-1: Summary of Calibration Frequency and Criteria (cont'd)

MTBE	Same as BTEX	Same as BTEX	Same as BTEX
Total Phenol	Calibrate at start of each run Check calibration after every 10 non-calibration analyses	Initial Calibration: Six-point standard curve Method Blank Continuing Calibration: Mid point standard Blank	Initial: Correl. Coeff. $\geq$0.995 Blank <RDL Continuing: CCV $\pm$10% of Theo. Value Blank <RDL
Total Suspended Solids	Calibrate balance daily NIST traceable weights	QC standard each run Blank	QC std within supplier specifications Blank < RDL
Surfactants (MBAS)	Calibrate at start of each run Check calibration after every 10 non-calibration analyses	Initial Calibration: Ten-point standard curve Method Blank Continuing Calibration: mid-range standard from alternative source standard (CCV) blank	Initial: Correl. Coeff. $\geq$0.995 Blank <RDL Continuing: CCV $\pm$10% of Theo. Value Blank <RDL
COD	Calibrate at start of each run Check calibration after every 10 non-calibration analyses	Initial Calibration: Three point standard curve, blank Continuing Calibration Check: mid-range standard from(CCV) blank	Initial: Correl. Coeff. $\geq$0.995 Blank <RDL Continuing: CCV $\pm$20% of Theo. Value Blank <RDL
PO_4-P	Calibrate at start of each run Check calibration after every 10 non-calibration analyses	Initial Calibration: Five point standard curve, blank Continuing Calibration Check: mid-range standard from alternative source standard (CCV) blank	Initial: Correl. Coeff. $\geq$0.995 Blank <RDL Continuing: CCV $\pm$10% of Theo. Value Blank <RDL
TKN	Same as PO_4-P	Same as PO_4-P	Same as PO_4-P
NH_3-N	Same as PO_4-P	Same as PO_4-P	Same as PO_4-P

Table 6-2: Summary of Analytical Accuracy and Precision Limits

Sample Matrix	Analyses	Reference Methods	Accuracy Percent Recovery	Precision Relative Percent Diff.
Water	pH	150.1	N/A	0-10
	TPH	EPA 1664A SGT-HEM	75-125	0-30
	TOC	EPA 415.2	80-120	0-20
	Oil & Grease	EPA 1664/HEM	60-140	0-25
	BETX	SW846-8021B	80-120	0-20
	MTBE	SW846-8021B	80-120	0-20
	Total Phenols	EPA 420.4	70-130	0-20
	Total Suspended Solids	EPA 160.2	N/A	0-30
	Metals	EPA 200.7, 200.8, 200.9	70-130	0-30
	Surfactants (MBAS)	EPA 425.1	50-150	0-20
	COD	EPA 410.4	80-120	0-20
	PO_4-P	EPA 365.1	80-150	0-10
	TKN	EPA 351.2	70-130	0-20
	NH_3-N	EPA 350.1	70-130	0-10
SOLID				
	TCLP	SW 846-1311	Varies by matrix	
	Total Suspended Solids		N/A	0-30

N/A - Not applicable

Laboratory blank water of known quality will be used for all laboratory analyses and water for final sample bottle rinsing for the TSS analysis. If contamination is detected in the blank water, the analysis will be stopped and the problem corrected. Laboratory blanks, method blanks and any other blank water data must be reported with all analytical results. One set of field blanks will be prepared and analyzed to verify bottle cleanliness and sample handling in the physical lab. One complete set of bottles (for all analyses) will be filled with distilled or deionized water and submitted for analyses. Travel blank samples will be collected randomly and sent with samples to be analyzed at the subcontract laboratory. The travel blank samples will be analyzed for BETX.

Laboratory control samples where applicable will be used to verify that the methods are performing properly. The control samples will be blank water spiked with constituents from standards obtained from certified source material. Lab control samples will be carried through the entire analysis including the digestion step in the case of the solid matrix.

Calibration of the pH meter will follow standard practice as given in the NSF SOP. The instrument will be calibrated using a two-point calibration with certified pH buffer solutions. The calibrated pH range (typically pH 4-7 or pH 7-10) will be selected based on the expected pH of the samples. Calibration is verified using an independent buffer solution in the calibrated range.

Calibration for the various analyses will be based on a minimum three-point calibration curve in the linear range of the method and instrument as detailed in the SOPs. The calibration sequence includes a method blank, three-five point calibration curve, and a standard check sample prepared from a secondary source, which must be within the limits shown in Table 6-2. The calibration is checked after each group of ten samples. If the calibration check results fall outside the acceptance criteria, the instrument is recalibrated and the affected samples are analyzed again. Table 6-2 provides calibration information and other run sequence information.

Balances are calibrated each day with NIST traceable weights. A calibration logbook is maintained to demonstrate the balances are accurate.

6.3.4 DATA REDUCTION, HANDLING, AND REPORTING

6.3.4.1 Reporting Units Requirements

All analytical results will be reported in standard units of mg/L, µg/L, mg, grams, etc. Flow rates and volumes will be reported as gallons and gallons per minute. Analysis of solids will clearly indicate if the concentration is on a dry weight or weight basis. Table 6-3 shows a summary of the reporting units.

Table 6-2: Standard Reporting Units

Parameter	Units
pH	S.U.
TPH	mg/L
TOC	mg/L
Oil & Grease	mg/L
BETX	µg/L
MTBE	µg/L
Total Phenols	mg/L
Total Suspended Solids	mg/L
Metals	mg/L
Surfactants (MBAS)	mg/L
COD	mg/L
PO_4-P	mg/L
TKN	mg/L
NH_3-N	mg/L
TCLP	mg/L
Total Solids	%
Flow	gpm
Volume	gallons
Residue weight	grams

6.3.4.2 Documentation

All of the field and laboratory activities will be thoroughly documented by the use of field logbooks, project approval/chain of custody sheets, laboratory notebooks and bench sheets, and instrument records.

A field logbook will be maintained at the NSF Hydraulics Laboratory. Daily activity entries will be made in the logbook documenting operating conditions, observations, and maintenance activities, if any are needed. Each sample collected will be noted in the logbook and any other pertinent information will be recorded. Completed pages in the logbook will be signed and dated.

Original project approval and chain of custody forms will accompany all sample(s) sent to the Chemical Laboratory and will be maintained by the NSF sample management group. The laboratory will produce a final data report that includes all chemical test results, physical measurements, QA/QC data for blanks, accuracy (recovery), and precision (percent difference), and lab control or matrix check samples. Any deviations from the standard protocols will be discussed in a narrative, any data that does not meet the QA/QC requirements will be flagged, and a narrative will be prepared discussing the findings of any corrective action.

The laboratory will maintain all logbooks, bench sheets, instrument printouts, etc. in accordance with the NSF laboratory QA/QC Manual. The QA/QC or Laboratory Coordinator will make these records available for inspection upon request.

6.3.4.3 Document Handling

During the test period the original field logbook will be kept at the Hydraulics Laboratory. At the end of the test period, the original logbook will be sent to the NSF VO manager for storage in a secure central project file. Original laboratory data reports with the original project approval forms and chain of custody will be placed in the central project file at NSF. Copies of these reports and any electronic data will be sent to the Project Manager (TO) and QA/QC officer for review. Other copies of the data or logbooks may be distributed to other project team members.

6.3.4.4 Data Reduction and Validation

All measurements and analytical results will be reported in units that are consistent with the methods used and as shown in Table 6-4. The laboratory analysts will record raw data in laboratory notebooks or bench sheets using standard formats. Each analytical method will contain instructions for recording and calculating the results. The laboratory analyst will have primary responsibility to verify that the results recorded are accurate. Data review and QA/QC review will be the responsibility of the NSF laboratory staff following the NSF standard data review and verification procedures for the laboratory. Data transcribed for entry to a computerized database will be checked against the lab bench sheets or instrument printouts by a second person. The same procedure will be followed for any electronic reporting of data, such as the Excel spreadsheet that is required for final data submittal. The final data report will be signed by an authorized laboratory manager/supervisor in accordance with laboratory policy.

The final data reports and electronic data received by the project team from the laboratory will be 100% checked. The Project Manager (TO) or designee will cross check 100% of the data in the final reports from the laboratory with a printout of the spreadsheet provided by the laboratory. The QA/QC officer for the VO will review the final data reports and all QA/QC information.

The QA/QC officer will issue a QA/QC review report discussing the quality of the data, how it compares to the Data Quality Objectives, and any data that should be flagged as invalid or questionable. The VO Project Coordinator will back check 100% of the draft Verification Report data tables and calculations with the laboratory data and spreadsheets provided by the TO.

6.4 ASSESSMENTS

The project QA/QC officer or a designee will be responsible for making announced and unannounced field and laboratory audits to observe adherence to the cleaning/operational protocols, sample collection methodology, sample handling practices, and analytical procedures detailed in the VTP. The QA/QC Officer will review logbooks and final data reports to ensure that these records meet the DQI requirements and other requirements for the VTP. The Project Manager (TO) or a designee and the QA/QC Officer (part of the TO team) will validate data, as it is received from the laboratory.

The NSF Chemical Laboratory has an assessment program that includes internal and external audits, Quality reports to management, and other internal checks are part the system used to ensure the NSF QA/QC procedures are being implemented and maintained. The NSF assessment procedures will be part of the QA/QC program and will be followed during the time the analytical work is being performed for the verification test.

At least one field audit will be conducted by the VO (NSF ETV Program QA/QC staff or Project Coordinator VO) during the test. The audit(s) will be to observe the sample collection procedures being used, to observe operation of the unit, condition of the test site, and to review the field logbook(s). A written report will be prepared by the auditor and submitted to the QA/QC Officer and the Project Coordinator. At least one lab audit will be performed during the test to observe sample receipt, handling, storage, and to confirm that the proper analytical methods, QA/QC procedures and calibrations are being used.

6.5 CORRECTIVE ACTION

Field related activities that could require corrective action include problems with sample collection, labeling, and improper entries or missed entries in logbooks or operational problems with the unit. The primary person responsible for monitoring these activities will be Patrick Davison with audits by the NSF designated staff. If a problem occurs, the problem will be noted in the field logbook and Mr. Davison will notify the VO in all cases and the vendor in the case of Hydro-Kleen™ unit operating issues. The problem, once identified will be corrected. If a change in field protocol related to sample collection or handling is needed, the change will be approved by the NSF ETV Project Manager. All corrective action required will be thoroughly documented and discussed in the Verification Report.

Laboratory corrective action will be taken whenever:

- There is a non-conformance with sample receiving or handling procedures;
- The QA/QC data indicates any analysis is out of the established control limits;
- Audit findings indicate a problem has occurred; and/or
- Data reporting or calculations are determined to be incorrect.

The NSF Chemical Laboratory has a formal Corrective Action Plan as part of the QA/QC Manual. These procedures will be followed including notifying the laboratory QA/QC Manager and the TO QA/QC Officer. All corrective action will be thoroughly documented and reported to the TO. All data impacted by a correction will be so noted and a discussion of the problem and corrective action will be included with the data report.

All corrective actions, either in the field or in the laboratory, will be reported to the VO Project Coordinator. The VO will review the cause of the problem and the corrective action taken by the TO. The review will include consideration of the impact of the problem on the integrity of the test and make a determination if the test can continue or if additional action is needed. Additional action could include adding additional days to the test period, re-starting the test at day one, or other appropriate action as determined by the VO. The VO will respond to any notification of corrective action within twenty-four hours of being notified of the problem. This response can be to continue the testing, cease testing until further notice, or other appropriate communication regarding the problem. The response by the VO will be in writing by email, fax, or letter.

7.0 DATA MANAGEMENT AND ANALYSIS

Several types of data will be collected or generated during the testing periods. Quantitative data, including flow data, influent and effluent water quality data, type and amount of residuals generated, etc., will be measured and reported by the laboratory. Qualitative data describing the setup, operation, and maintenance of the Hydro-Kleen™ unit will collected throughout the test period. All of this information will be managed during the verification using methods outlined in this section. The test results will be analyzed and presented in the Verification Report using a standardized approach, which is described in Section 7.3.

7.1 DATA MANAGEMENT

The data being collected during this verification will include both manual and electronic data collection and storage methods. Field and laboratory notebooks will be maintained to document all activities related to the sampling, operation, and maintenance activities at the site, and to document sample handling, equipment calibrations, and other related activities in the laboratory. Laboratory results will be reported in paper reports showing all of results and QA findings for each set of data. These results will then be entered into Excel spreadsheets for ease of analysis and storage.

All samples collected in the field or prepared in the laboratory will be assigned a specific identification number that will be used to track and record the data throughout the collection, analysis, and data reporting steps. The numbering system will include the use of an identifier for the test phase associated with the sample (characterization or verification), an identifier of sample type (solid, liquid, residual), sample location (influent, effluent) and the date of collection. The field sampling personnel will assign the sample number for all samples collected on-site. The samples collected in the field will have a clear label with the sample number and date on the label. The project approval form and/or chain of custody sheet accompanying the sample(s) to the laboratory will also show this sample identification number. The laboratory will also be generating samples and sub-samples during the test. The laboratory will assign unique identification numbers to these sub-samples that will clearly identify their nature and will tie back directly to the sample identification assigned in the field. The laboratory data reports will show the sample identification numbers and will include copies of the project approval and chain of custody forms that clearly track the sample names from their assignment in the field through the analysis in the laboratory.

7.1.1 MANUAL DATA COLLECTION

All data collection, observations, and sample records will be written in a field logbook maintained at the site by field personnel. Copies of these records will then be reviewed by the TO Project Manager or a designee to ensure the records are being properly maintained. At the end of the verification test, the field log will become part of the permanent record for this verification test.

The laboratory will use laboratory notebooks to record all manual data and related information in accordance with good laboratory practice and the laboratory QA/QC and SOP documents. The laboratory logbooks will be available for review by the Quality Assurance Officer or Project Coordinator at any time. The laboratory will be responsible for maintaining and archiving the notebooks and manual records that support the data reported by the laboratory. The original project approval and chain of custody records and any appropriate supporting documents will be provided with the data reports. The data reports will include a discussion of any problems that occurred during the analysis, corrective action taken, and any other factors that could impact the data. The laboratory reports will include all QA/QC results, including blanks, spikes, duplicates, check samples, etc., such that the Quality Control Officer can validate the data and make an independent opinion as to the quality and acceptability of the data.

7.1.2 ELECTRONIC DATA COLLECTION

The laboratory will provide the analytical results in both hard copy reports and in electronic format. The data will be entered into an Excel spreadsheet in a format that will be finalized and provided by the laboratory coordinator. The laboratory will verify the data in the spreadsheet by comparing a print out of the spreadsheet with the hard copy results and their supporting documents prior to release of the data.

Upon receipt of the laboratory reports and spreadsheets, the Project Manager (TO), QA Officer or their designee will verify the accuracy of the data. A direct comparison of the hard copy data and the electronic spreadsheet will be made. Any corrections required will be written on the print out of the spreadsheet and the corrections made to the spreadsheet.

7.2 DATA ANALYSIS AND PRESENTATION

All results, including statistical analysis, will be provided in the Verification Report. Any data that was excluded in statistical analysis will be reported with an explanation as to why it was not included in the analysis. The data obtained during verification testing will be statistically analyzed, reduced, and presented in tables, graphs and charts. All raw data will be included as an appendix to the Verification Report. The statistical methods and any statistical programs used will be described in the Verification Report. A detailed discussion of the results will accompany the tables, graphs and/or charts and shall be presented in the Verification Report (see Section 7.3). Conclusions drawn from the analysis of the test results will be presented in the Verification Report.

7.2.1 FLOW DATA

The Hydraulics Laboratory will collect flow data during all four Phases of verification testing. The total flows and flow rate for each Phase, day, or activity will be summarized in a spreadsheet. The results will be presented in the final report as a table showing average, maximum, and minimum daily flow.

7.2.2 TREATMENT PERFORMANCE QUALITY DATA

Valid wastewater quality data obtained during the verification test will be analyzed and presented as follows:

- Tables showing the average, maximum and minimum influent concentration for the sampling events for the target contaminate list;
- Tables showing the average, maximum and minimum effluent concentration for the sampling events and removal efficiency for the target contaminate list;

- Table(s) showing the mass of the residual stream.

7.2.3 OPERATIONS AND MAINTENANCE PARAMETERS

Results of monitoring operation and maintenance parameters during verification testing shall be presented in a discussion format. The Verification Report will include a thorough discussion of any difficulties encountered in operating or maintaining the unit during the verification test. Discussion will include observations regarding the ease/difficulty of installation and factors such as operator training, presentation clarity in the O&M manual, etc.

7.2.4 EQUATIONS

The data analysis will include the calculations of removal efficiency and various statistics. The equations to be used in the data analysis are provided below.

Removal Efficiency $\dfrac{\text{(mg/L influent – mg/L effluent)}}{\text{(mg/L influent)}} \text{ X } 100\%$

Sample Mean (Average) $y_{bar} = \Sigma v / n$

Where:

y_{bar}	is the sample mean
Σv	is the sum of the sample values
n	is the number of samples

Standard Deviation $s = (\Sigma (y - y_{bar})^2 /n)^{1/2}$

Where:

s	is the sample standard deviation
y	is an individual sample value
y_{bar}	is the sample mean

95% Confidence Interval $= y_{bar} \pm t_{\alpha/2} (s / n^{1/2})$

Where:

y_{bar}	is the sample mean
s	is the sample standard deviation
n	is the number of samples
$t_{\alpha/2}$	is the Student's t-distribution with n-1 degrees of freedom, with $\alpha/2=0.025$
$t_{\alpha/2}$	= 2.068 for n=25

7.3 VERIFICATION REPORT

The Verification Report will be a document containing all raw and analyzed data, all QA/QC data sheets, a description of all types of data collected, a detailed description of the testing procedure and methods, results and QA/QC results. The Report will thoroughly present and discuss the findings of the verification test. Conclusions regarding the performance of the Hydro-Kleen™ Unit will be made and compared with the performance goals for the verification test.

It is expected that the Verification Report will contain the following main sections. There may be some deviation from the order given below in order to present the findings in a clear and precise manner. Additional sections will be added as needed to properly present all of the findings.

- Verification Statement
- Preface
- Glossary
- Acknowledgements
- Executive Summary
- Introduction and Background
- Procedures and Methods Used In Testing (summarizing essential information from the Test Plan)
- Results and Discussion
- Limitations
- Conclusions
- Recommendations
- References
- Appendices
    - Raw Data
    - Special Laboratory Procedures – Standard Operating Procedures
    - QA/QC Manual/Procedures
    - O&M Manual

Field logs and supporting documentation as appropriate.

8.0 REFERENCES

(1) NSF International, *Protocol for the Verification of In-Drain Treatment Technologies*, April 2001. Ann Arbor, Michigan.

(2) United States Environmental Protection Agency: *Environmental Technology Verification Program - Quality and Management Plan for the Pilot Period (1995 – 2000)*, USEPA/600/R-98/064, 1998. Office of Research and Development, Cincinnati, Ohio.

(3) NSF International, *Environmental Technology Verification – Source Water Protection Technologies Pilot Quality Management Plan*, 2000. Ann Arbor, Michigan.

(4) United States Environmental Protection Agency: *Methods and Guidance for Analysis of Water*, EPA 821-C-99-008, 1999. Office of Water, Washington, DC.

(5) United States Environmental Protection Agency*: Methods for Chemical Analysis of Water and Wastes,* Revised March 1983. EPA 600/4-79-020.

(6) United States Environmental Protection Agency*: Test Methods for Evaluating Solid Waste: Physical/Chemical Methods 3rd ed - 4 vols.,* November 1986. Final Update IIB and Proposed Update III, January 1995.

(7) APHA, AWWA, and WEF: *Standard Methods for the Examination of Water and Wastewater, 20th Edition,* 1998. Washington, DC.

(8) United States Environmental Protection Agency: *USEPA Guidance for Quality Assurance Project Plans, USEPA QA/G-5*, USEPA/600/R-98-018, 1998. Office of Research and Development, Washington, DC.

(9) United States Environmental Protection Agency, *Guidance for the Data Quality Objectives Process, USEPA QA/G-4*, USEPA/600/R-96-055, 1996. Office of Research and Development, Washington, DC.

APPENDIX A – O&M MANUAL

Hydro-Kleen™ Filtration System

HYDRO COMPLIANCE MANAGEMENT, INC.
8741 Main Street, Suite K
Whitmore Lake, MI 48189 (734) 449-8860

This is SORB-44. This filter media goes on top of the AC-10 Filter.

Installation Instructions

Installation Instructions for a Hydro-Kleen™ Filtration System

1. Remove grate from catch basin.
2. Clean rim of catch basin with wire brush or broom.
3. Remove diverter (plastic plate with Hydro Compliance Logo)
4. Remove filter media.
5. Place unit in opening.
6. Remove plastic covering from (2) Sorb-44 and (1) AC-10 media bags.
7. Place AC-10 Filter (carbon) flat on the bottom of chamber with holes. Seamed side up.*
8. Lay the Sorb 44 Filters flat on top of carbon bag. Seamed side up.*
9. Replace diverter on top of the chamber with media.
10. Replace the grate.
11. Properly dispose of plastic bags.

* You will notice the shape of the media bags fit the shape of the filter chamber.

Hydro-Kleen™ Filtration System

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This is SORB-44. This filter media goes on top of the AC-10 Filter.

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5. Place unit in opening.
6. Remove plastic covering from (2) Sorb-44 and (1) AC-10 media bags.
7. Place AC-10 Filter (carbon) flat on the bottom of chamber with holes. Seamed side up.*
8. Lay the Sorb 44 Filters flat on top of carbon bag. Seamed side up.*
9. Replace diverter on top of the chamber with media.

10. Replace the grate.
11. Properly dispose of plastic bags.
    *You will notice the shape of the media bags fit the shape of the filter chamber.

Hydro-Kleen™ Filtration System

HYDRO COMPLIANCE MANAGEMENT, INC.

8741 Main Street, Suite K

Whitmore Lake, MI   48189 (734) 449-8860

Installation Instructions for Replacement Media:

1. Remove grate from catch basin.
2. Remove diverter (plastic plate with Hydro Compliance Logo)
3. Remove used filter media.
4. Clean sediment chamber.
5. Remove plastic covering from (2) Sorb-44 and (1) AC-10 media bags.
6. Place AC-10 Filter (carbon) flat on the bottom of chamber with holes. Seamed side up.*
7. Lay the Sorb 44 Filters flat on top of carbon bag. Seamed side up.*
8. Replace diverter on top of the chamber with media.
9. Replace the grate.
10. Properly dispose of plastic bags, used media and sediment according to applicable regulations.

__Warning:__ Filtration media is not for human consumption. Do not eat or inhale the materials.

Need to order new media? Contact your sales representative or call Hydro Compliance Management, Inc. (734) 449-8860 or visit us on the web at www.hydrocompliance.com. We accept Visa, Mastercard and American Express for your convenience.

Revision Date 09-2000

Hydro-Kleen™ Filtration System

HYDRO COMPLIANCE MANAGEMENT, INC.

8741 Main Street, Suite K

Whitmore Lake, MI   48189 (734) 449-8860

Installation Instructions for Replacement Media:

11. Remove grate from catch basin.
12. Remove diverter (plastic plate with Hydro Compliance Logo)
13. Remove used filter media.
14. Clean sediment chamber.
15. Remove plastic covering from (2) Sorb-44 and (1) AC-10 media bags.
16. Place AC-10 Filter (carbon) flat on the bottom of chamber with holes. Seamed side up.*
17. Lay the Sorb 44 Filters flat on top of carbon bag. Seamed side up.*

18. Replace diverter on top of the chamber with media.
19. Replace the grate.
20. Properly dispose of plastic bags, used media and sediment according to applicable regulations.

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Revision Date 09-2000

Hydro-Kleen™ Filtration System

HYDRO COMPLIANCE MANAGEMENT, INC.
8741 Main Street, Suite K
Whitmore Lake, MI 48189
(734) 449-8860

This is an AC-10 Filter. This filter media goes on bottom of the filter chamber with holes in the bottom.

Installation Instructions

Installation Instructions of a Hydro-Kleen™ Filtration System:

1. Remove grate from top of catch basin.
2. Clean rim of catch basin with wire brush or broom.
3. Remove diverter (plastic plate with Hydro Compliance Logo)
4. Remove filter media.
5. Place unit in opening.
6. Remove plastic covering from (2) Sorb-44 and (1) AC-10 media bags.
7. Place AC-10 Filter (carbon) flat on the bottom of chamber with holes in bottom. Seamed side up.*
8. Lay the Sorb 44 Filters flat on top of carbon bag. Seamed side up.*
9. Replace diverter on top of the chamber with media.
10. Replace the grate.
11. Properly dispose of plastic bags.
    * You will notice the shape of the media bags fit the shape of the filter chamber.

Hydro-Kleen™ Filtration System

HYDRO COMPLIANCE MANAGEMENT, INC.
8741 Main Street, Suite K
Whitmore Lake, MI 48189
(734) 449-8860

This is an AC-10 Filter. This filter media goes on bottom of the filter chamber with holes in the bottom.

Installation Instructions

Installation Instructions of a Hydro-Kleen™ Filtration System:

12. Remove grate from top of catch basin.
13. Clean rim of catch basin with wire brush or broom.
14. Remove diverter (plastic plate with Hydro Compliance Logo)
15. Remove filter media.
16. Place unit in opening.
17. Remove plastic covering from (2) Sorb-44 and (1) AC-10 media bags.

18. Place AC-10 Filter (carbon) flat on the bottom of chamber with holes in bottom. Seamed side up.*
19. Lay the Sorb 44 Filters flat on top of carbon bag. Seamed side up.*
20. Replace diverter on top of the chamber with media.
21. Replace the grate.
22. Properly dispose of plastic bags.
    * You will notice the shape of the media bags fit the shape of the filter chamber.

Hydro-Kleen™ Filtration System

HYDRO COMPLIANCE MANAGEMENT, INC.
8741 Main Street, Suite K
Whitmore Lake, MI 48189
(734) 449-8860

Installation Instructions for Replacement Media:

1. Remove grate from catch basin.
2. Remove diverter (plastic plate with Hydro Compliance Logo)
3. Remove used filter media.
4. Clean out sediment chamber.
5. Remove plastic covering from (2) Sorb-44 and (1) AC-10 media bags.
6. Place AC-10 Filter (carbon) in chamber with holes in the bottom. Seamed side up.
7. Place Sorb 44 Filters on top of carbon bag. Seamed side up.
8. Replace diverter on top of the chamber with media.
9. Replace the grate.
10. Properly dispose of plastic bags, used media and sediment according to applicable regulations.

Warning: Filtration Media is not for human consumption. Do not eat or inhale the materials.

Need to order new media? Contact your sales representative or call Hydro Compliance Management, Inc. (734) 449-8860 or visit us on the web at www.hydrocompliance.com. We accept Visa, Mastercard and American Express for your convenience.

Revision Date 02-2001

Hydro-Kleen™ Filtration System

HYDRO COMPLIANCE MANAGEMENT, INC.
8741 Main Street, Suite K
Whitmore Lake, MI 48189
(734) 449-8860

Installation Instructions for Replacement Media:

11. Remove grate from catch basin.

12. Remove diverter (plastic plate with Hydro Compliance Logo)
13. Remove used filter media.
14. Clean out sediment chamber.
15. Remove plastic covering from (2) Sorb-44 and (1) AC-10 media bags.
16. Place AC-10 Filter (carbon) in chamber with holes in the bottom. Seamed side up.
17. Place Sorb 44 Filters on top of carbon bag. Seamed side up.
18. Replace diverter on top of the chamber with media.
19. Replace the grate.
20. Properly dispose of plastic bags, used media and sediment according to applicable regulations.

Warning: Filtration Media is not for human consumption. Do not eat or inhale the materials.

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Revision Date 02-2001

HYDRO-KLEEN Catch Basin
Sedimentation and Contaminant Filtration System

Description

Hydro - Kleen Filter Systems are a cost effective technology available for use with stormwater catch basins or drains to trap sediments and substantially reduce contaminant levels from stormwater and other non-point source runoff.

These multi-media filtration systems contain design features which address concerns dealing with sedimentation and water flow issues while effectively filtering out hydrocarbons and other toxins. When utilized with a regular maintenance program Hydro-Kleen is an effective Best Management Practice (BMP) to assist governments and private business in meeting NPDES and other water runoff requirements for protecting surface water quality.

Application

Hydro-Kleen is a patented system which utilizes a multi-media filtration design combined with sedimentation containment and overflow protection. Each unit is manufactured to fit the catch basin or drain it is inserted into. The units are placed into existing catch basins by removing the cover or grate, inserting the unit into the basin and replacing the cover. Water flow enters the unit and is directed into a sedimentation chamber that collects course sedimentation and debris, which passes through the grate cover. The water then passes from the sedimentation side through a transition inlet at the top of the sedimentation chamber into the filtration side. The first media (Sorb44) catches Hydrocarbon contaminants through absorption to a hydrophobic pulp material. The second media is an activated carbon (AC10), which polishes any remaining Hydrocarbons in the water and removes a variety of organically bound metals and other contaminants that may be in the runoff. The water then passes through the bottom into the catch basin or drainpipes.

The unit must be maintained on a regular schedule to prevent saturation of the filter media by contaminants and blockage from sedimentation and debris buildup.

Maintenance is simple and can be accomplished by merely removing the cover, vacuuming debris from the sedimentation chamber and replacing the filters. The maintenance of each unit takes only minutes and can be done with minimal instruction. A typical recommended change out of the filters would be every 4 to 6 months. Sedimentation maintenance may be needed more often depending on the location and season. A clean out after heavy leaf fall is recommended.

Certified laboratory tests of the media produced reduction of Hydrocarbon and other contaminants to non-detect levels. (See attached results.) A properly maintained unit will achieve substantial reduction of contaminants into the surface water. The units are designed to trap contaminants contained in the "first flush" from storm events while allowing overflow protection to ensure sufficient flow to prevent flooding from back up during heavy wet weather events. Street units strategically placed downstream from sites which contain higher contaminant levels, such as gas stations, parking lots and industrial sites, give municipalities and businesses an effective tool for reducing non-point source pollutants in their systems.

Hydro-Kleen filter systems are also cost effective and can be installed at a fraction of the cost of conventional oil-water separators and other BMP's. A typical unit costs about two thousand dollars and the media can typically be replaced for less than four hundred dollars including labor per change out. Moreover, Hydro-Kleen does not require expensive installation and labor costs as it can fit into most existing catch basins.

Disposal of the media in a typical drain system such as for use with streets and parking lots can be accomplished through placements into class II landfills since the filter media is non-leaching. Applications for other uses may require disposal with a license facility depending on the contaminant load.

Hydro-Kleen can also be an effective pre-treatment system used in conjunction with other BMP's such as detention facilities or other types of water retention systems as well as oil grit separators. The use of Hydro-KleenSystems can also free up land use on smaller sites which would otherwise be set aside for detention basins or traditional and expensive oil-water separators.

With the new NPDES Phase II rules aimed at smaller municipalities and business sites combined with the increased emphasis on watershed protection at the local, state and federal levels, Hydro-Kleen Filter Systems provide an effective and low cost technology in achieving substantial reduction of sediments and contaminants in nonpoint source and other runoff.

Third Party Testing Results
for the Hydro-Kleen Filtration System

Containment	Initial Concentration	After Filtration*	MDL/PQL
EPA 8015/8020/8021			
Gasoline	100,000 ppb	N.D.*	50 ppb
Toluene	46,000 ppb	N.D.*	5 ppb
2-Methylpentane	9,000 ppb	N.D.*	5 ppb
2-Methylheptane	8000 ppb	N.D.*	3 ppb
Benzene	28,000 ppb	N.D.*	10 ppb
Xylene	66,000 ppb	N.D.*	16 ppb
2-Methylhexane	1500 ppb	N.D.*	10 ppb
Trimethylhexane	4700 ppb	N.D.*	15 ppb
EPA 8270			
Diesel	100,000 ppb	N.D.*	50 ppb
EPA 413/418/1664			
Oil and Grease	100,000 ppb	N.D.*	.02 ppb
EPA 601			
1,1-Dichloroethane	17,000 ppb	5 ppb	3 ppb
Chloromenthane	20,000 ppb	N.D.*	2 ppb
EPA 603			
Acrylonitrile	11,000 ppb	4 ppb	3 ppb
Anthracene	15,000 ppb	N.D.*	20 ppb
EPA 608			
PCB's	50,000 ppb	5 ppb	20 ppb
Chlordane	20,000 ppb	N.D.*	25 ppb
Aldrin	20,000 ppb	N.D.*	20 ppb
Endrin	20,000 ppb	N.D.*	10 ppb
Heptachlor	20,000 ppb	N.D.*	5 ppb
EPA 610			
Phenanthrene	6,000 ppb	N.D.*	7 ppb
Benzo(a)pyrene	12,000 ppb	N.D.*	40 ppb
Chrysane	7,000 ppb	N.D.*	30 ppb

EPA 613			
Dioxins (2,3,7,8-TCDD)	10,000 ppb	4 ppm	

***N.D.**
("non detect"at or below method detection limits)

Comments:
The results indicate that the two media used in tandem, under ideal conditions, can be extremely efficient at moving a wide range of hydrocarbons, petroleum distillates, and related organic compounds from an aqueous matrix.

Note:
Methods from EPA, 40CFR Part 136: SW846 (Test Methods for Evaluating Solid Wastes): and EPA 600/4-79-020 (Methods for Chemical Analysis of waters and Wastes)

APPENDIX B - BYPASS HYDRAULIC CALCUALTIONS

Hydro Compliance Management , Inc.
Flow Rate Calculations for a Hydro-Kleen Filtration System

From East Jordan Iron Works $Q = 0.0108A\sqrt{d}$ Where $d \geq 4$"

Q = Flow in CFS (cubic feet per second)

A = Clear Grate Opening in square inches - in²

d = Depth of Water Over Grate in inches

For an East Jordan Iron Works #5105 $A = 175$ in²

$Q = 0.0108(175)\sqrt{4}$

$Q = 3.78$ CFS or ≈ 1,700 gpm

A. If $\frac{1700 \text{ gpm}}{175 \text{ in}^2}$ then 9.7 gpm/in² of opening

The Hydro-Kleen Filtration System has holes 2 ⅜" diameter or 2.375" d.

$r = d/2$; $r = 1.188$ Area $= \pi r^2$; $\pi(1.188)^2 = 4.42$ in²/hole ˚ 32 holes = 144.44 in² (overflow only)

By Bernoulli;s eqn: $\frac{v_1}{2_g} + \frac{p_1}{\acute{Y}} + z_1 = \frac{v_2}{2_g} + \frac{p_2}{\acute{Y}} + z_2$

With pressure = 0 $p_1 = p_2 = 0$

With Elevation datum through p_2 $Z_1 = H$
$Z_2 = O$

Assume Velocity @ p_1. = 0

$0 + 0 + H = \underline{V_2} + 0 = 0$

$2g$

$V^2 = H(2g)$
$V^2 = 1(32.2\ ft/s)$

Discharge $Q = A_2 V_2$ $A_2 = 4.43\ in^2$ $V_2 = 32.2\ ft/s$

$(4.43\ in^2 \times \frac{1\ ft^2}{144\ in^2})$ $(32.2\ ft/s = 0.991\ ft^3/s$ (CFS)

B. Each hole under constant 1 ft. head would discharge about 1 CFS. Head would not be considered unless water was not being added to P_1 (as in a tank).

Total flow for a Hydro-Kleen Filtration System should be:

From A: $141.44\ in^2 (\frac{9.7\ gpm}{in^2}) = 1{,}371.97$ gpm or 3.05 CFS + 50 gpm filter = 3.16 CFS

The calculated EJIW unit flooded 4” = 2.78 CFS

Or

From B: Under 1 ft of water each 2 ⅜” hole yields .991 CFS @ 1 ft EJIW 5105 = 4.8 CFS

A standard unit has thirty-two (32) 2 ⅜” overflow holes.

Conclusion: Overflow holes in the product are larger than grate openings. This should prevent clogging of the unit under any circumstance.

Appendix C

Project Approval Form and Chain of Custody Form

PROJECT APPROVAL FORM (DC#: AC-841-0015)

Date:________________ PAF#______________

Company Name:____

Company #: ____________ Date Received: ____________ Requestor: ____________

Project #: ____________ Result Due Date: ____________ Region: ____________

Report Due Date: ____________

Job Description (be brief):____

Total Number of Samples:____________________

Invoiced by Data Control: ~ Invoiced by the Requestor: ~

Sample Description	Template	Test Code	Test Name
1.__________________________	____________	__________________	______________________
Lab Instructions:	____________	__________________	______________________
	____________	__________________	______________________
	____________	__________________	______________________
	____________	__________________	______________________
2.__________________________	____________	__________________	______________________
Lab Instructions	____________	__________________	______________________
	____________	__________________	______________________
	____________	__________________	______________________
	____________	__________________	______________________
3.__________________________	____________	__________________	______________________
Lab Instructions	____________	__________________	______________________
	____________	__________________	______________________
	____________	__________________	______________________
~ Additional Samples on Back	____________	__________________	______________________

Disposition of samples after completion of project:____

Note: Report formats other than those available in LIMS are the responsibility of the requesting party.

Responsible Areas:

Chemistry-Inorg:	______________________________	**Date:**________	**Comment:**________
Chemistry-Org:	______________________________	**Date:**________	**Comment:**________
Physical:	______________________________	**Date:**________	**Comment:**________
Micro:	______________________________	**Date:**________	**Comment:**________
Data Control:	______________________________	**Date:**________	**Comment:**________

Sample Description	Template	Test Code	Test Name
4.________________ Lab Instructions:			
5.________________ Lab Instructions			
6.________________ Lab Instructions			
7.________________ Lab Instructions			
8.________________ Lab Instructions			
9.________________ Lab Instructions			
10._______________ Lab Instructions			
11._______________ Lab Instructions			